POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

VOL. XXIV CHICAGO, SEPTEMBER 1, 1920 No. 17

Woodshop Waste Runs Power Plant

FOUR OF SEVEN BOILERS AT NEW WORKS OF GENERAL MOTORS CO. EQUIPPED FOR BURNING FACTORY REFUSE; CHEAP FUEL AND LARGE LOW-PRESSURE STEAM DEMAND RESULT IN LOWER POWER PRODUCTION COSTS

LOCATED BUT A FEW short blocks north of the end of the Natural Bridge Avenue car line is the most recently developed and that which promises to be the most important outlying industrial district of the city of St. Louis, Mo. Many new plants are not only in course of construction here, but are already in actual operation, and these plants at St. Louis, although as far as the St. Louis Manufacturing Corp. is concerned, it is a safe guess based upon the nature of the work done that the more ready ability to distribute the finished product was the governing factor. Except for the construction of enclosed bodies no manufacturing, strictly speaking, is done at these works. Essentially it is an assembly plant. Parts from the Buick and Chevrolet passenger

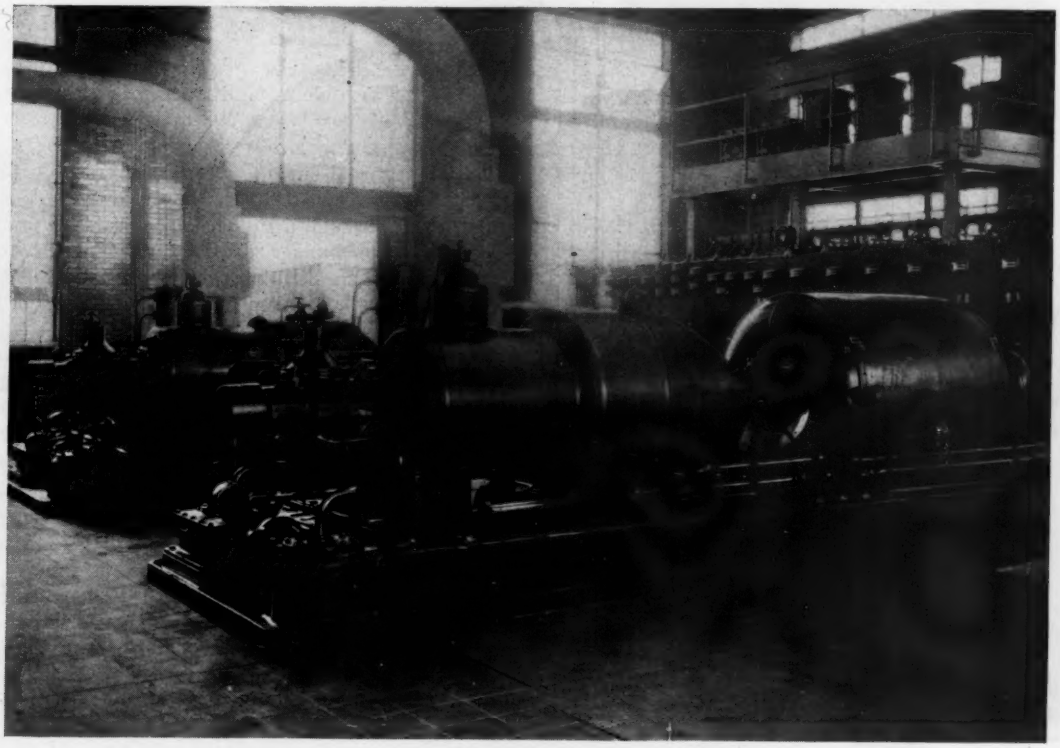


FIG. 1. GENERAL VIEW OF TURBINE ROOM

while some few of these may be those of corporations of mushroom growth, the majority and largest are either the main or subsidiary works of old-established manufacturing companies, such as the St. Louis Manufacturing Corp. Division of the General Motors Co., the United Drug Co., the General Electric Co., and others. Many reasons may undoubtedly be given for the location of car factories are shipped to the St. Louis plant and there assembled.

At present, there are seven buildings which, together with the surrounding grounds, occupy approximately 100 acres. All of the buildings except the woodworking plant are of brick and reinforced concrete construction three stories in height and are provided with the most

modern equipment and machinery. The power house, which is centrally located with reference to the other structures, covers a ground space of about 193 by 48 ft. on the boiler room side and somewhat more than 47 ft. on the turbine room side; the overall height of the building is approximately 65 ft. It is of steel, concrete

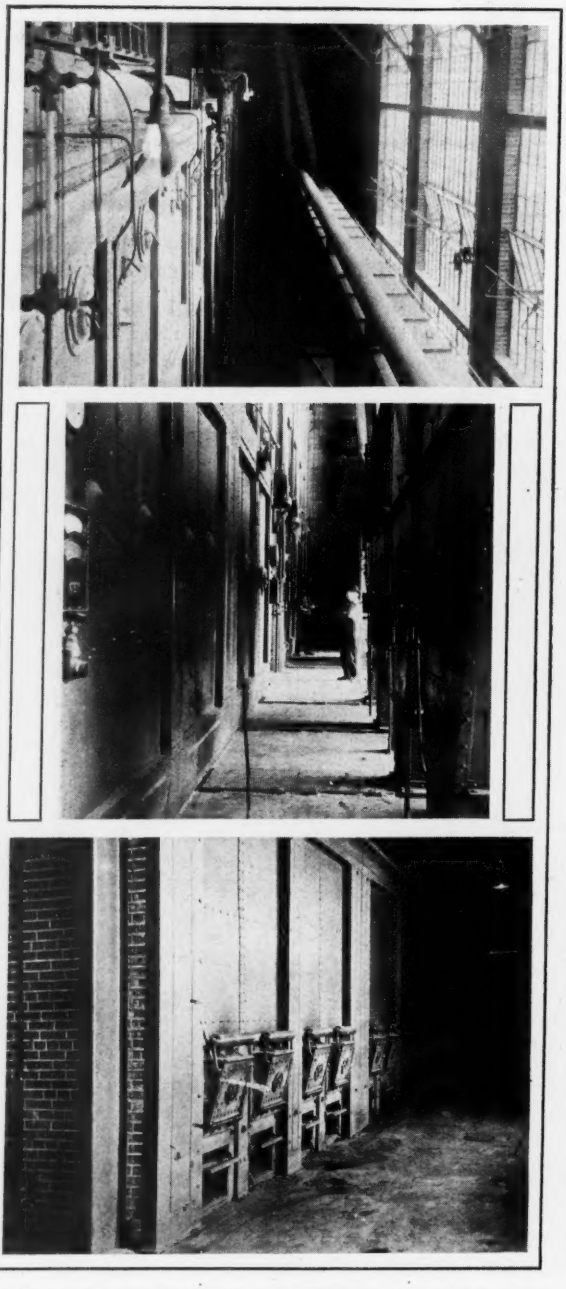


FIG. 2. VIEW IN BOILER ROOM SHOWING SHAVINGS CONVEYOR, DOWNSPOUTS TO FURNACES AND FURNACE FRONTS IN BASEMENT

and brick construction throughout the exterior facing, being of a tan color in conformity with the other buildings comprising the works. Interior of the turbine room is finished with a highly glazed brick of buff color with the lower part of the walls a dark red which, together with the red tile flooring, white pipe covering and black fittings, gives to the interior a very pleasing and harmonious appearance.

Exceptionally good illumination is secured by means of large windows placed along each outside and end wall. For night service, artificial illumination is provided by 200-w. nitrogen-filled lamps suspended from the overhead trusses, and fitted with enameled metal reflectors.

In the Boiler Room

Although many interesting features are to be found throughout the plant, those attracting the greatest attention of one interested in power plant engineering are in connection with the fuel-handling and steam-generating equipment. This is primarily due to the fact that both coal and wood are utilized, a number of the boiler furnaces being equipped for coal burning while the others are especially designed and constructed for the exclusive use of wood.

In Fig. 3 is shown an exterior view of the boiler house and adjoining concrete structures at each end, that at the right being utilized for the storage of the wood preparatory to firing, while that at the left houses the coal handling, conveying, storage and crushing equipment. In the foreground of this illustration may be seen the 1200-ton concrete bin employed for the submerged storage of coal and the 15-ton, 50-ft. boom steam-driven locomotive crane used for the general handling and transfer of this fuel.

Ordinarily the coal is delivered to the plant in cars, dumped into an underground track pit and by means of an apron conveyor is carried to a single-roll crusher for its reduction to a size consistent with the requirements of the coal-burning boiler stokers. A pivoted bucket conveyor driven by a 10-hp. electric motor then transports it through a tunnel and elevates it to a reinforced concrete bunker of 300-tons capacity located near the roof of the structure shown at the left of Fig. 3, and from where it is taken by means of a two-ton weigh larry as requirements demand. Before being delivered to the stoker hoppers, however, the coal is accurately weighed, a beam scale of the printing type having been installed for this purpose. An interior view of the end of the boiler room containing the coal-fired boilers and some of the boys who operate them is shown in Fig. 4.

Handling of the ashes is largely automatic. The consumed fuel is dumped into concrete receiving hoppers, built integral with the boiler settings, and so constructed and arranged as to allow of their ready discharge into cars which are pushed along tracks on the floor of the boiler room basement. A skip hoist is used to raise the ashes to a receiving pocket of approximately 50 tons capacity, from where they are fed through a 24 by 24-in. duplex cutoff valve into cars for final disposal.

All refuse from the woodworking shops is available for firing purposes. That not of such size and shape as to allow of its ready handling and consumption is reduced to the required size by means of a hog located in the body-building plant and driven by a 200-hp. wound rotor-induction motor. This, together with the regular shavings and sawdust, is then carried a distance of approximately 1000 ft. through an 11-in. sheet-iron pipe to the 1800-cu. ft. power house receiving and storage bin.

Air is used as the medium of transmission, this being provided by a blower direct connected to and driven by a 75-hp. induction motor.

Conveyance of the fuel from the concrete receiving bin to the distributing bin located directly in front of the boilers, as illustrated in Fig. 2, is by means of a V bucket conveyor operated by a 10-hp. motor. It is then delivered to the furnaces by means of screw conveyors driven by variable-speed electric motors each rated at 2½ hp. The two upper views shown in Fig. 2 well illustrate the construction and location of the V bucket conveyor, the storage bins, the down spouts leading to the screw conveyors and the rheostats for the control of the speeds of the conveyor motors. The rheostats are mounted on the boiler side of the storage bin, and, as may be seen, are within easy reach of the operators.

The present installation consists of seven water-tube boilers of the type shown in Fig. 7, each with a nominal rating of 626 hp. Three of these are equipped with furnaces designed for coal burning, and under-feed stokers, while the remaining four have settings such as to render them particularly well suited for the use of wood fuel. Sections through these furnaces are pictured in detail in Fig. 7. The furnace proper which is of a somewhat modified form of Dutch oven is placed below the floor of the boiler room and is fitted with grates, ash pit, and bridge wall similar to those used in connection with the ordinary hand-fired furnace. Two downspouts are provided for feeding the wood, the greater portion of which is burned in suspension. That not completely consumed, together with the ashes, is allowed to fall upon the grates, from where it is removed at regular intervals.

Some of the details of construction of these furnaces

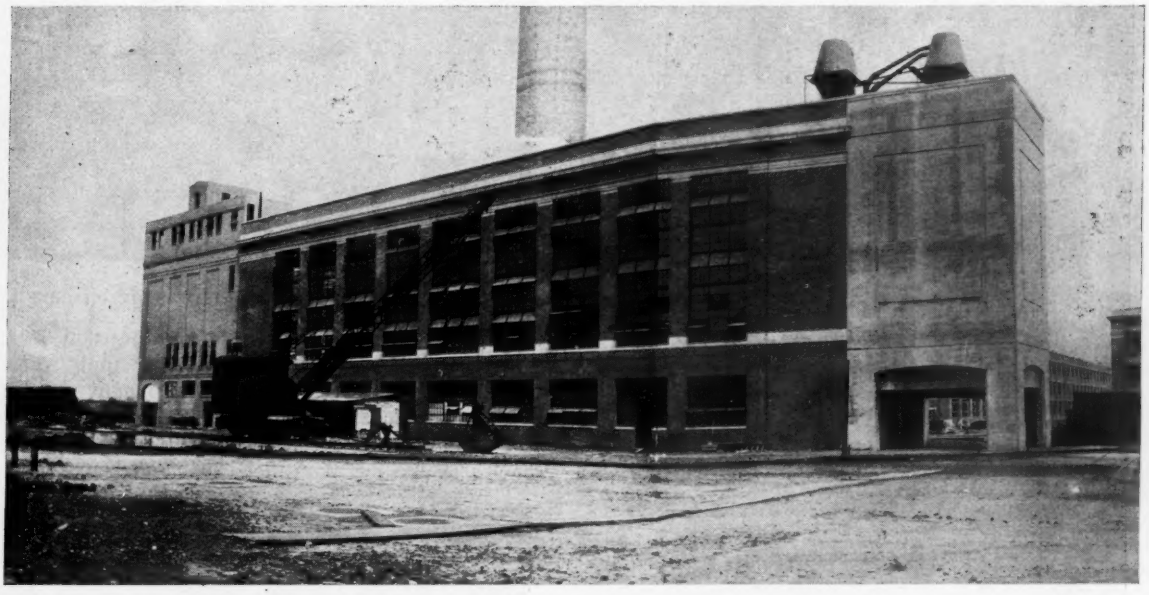


FIG. 3. AT THE LEFT END OF THE BOILER HOUSE IS THE COAL STORAGE AND HANDLING EQUIPMENT, WHILE AT THE RIGHT END IS THE SHAVINGS STORAGE BIN. THE SUBMERGED COAL PIT AND LOCOMOTIVE CRANE ARE IN THE FOREGROUND

A section through the boiler room storage bin, together with the relative location of the conveyor and the means of feeding the furnaces, is portrayed in Fig. 7.

The Steam Producers

Primarily this is a steam producing plant, the electric energy generated being essentially a by-product. The present maximum demand for electric energy frequently exceeds 10,000 kw. But, with conditions as existing at St. Louis, it was found more economical to install only such turbine capacity which at rated load would provide the amount of low-pressure steam required for heating and process work than that sufficient to carry the entire electrical load. It is estimated, however, that during the winter months the demand for low-pressure steam will be considerably in excess of that capable of being delivered by the turbines, and accordingly, the steam generating equipment is of such size as readily to furnish whatever steam may be required for both power generation and heating and process work.

are of interest. Each is divided into two compartments served by separate downspouts through which the fuel is fed. The grates have each a width of 5 ft. 5 in. and a length of 9 ft. and are placed approximately 2 ft. above the boiler room floor; the over-all furnace length is 16½ ft., while the height of the combustion chamber proper is 20 ft. 9 in. Above the relieving arch the furnace length is about 9¾ ft.

Each furnace is lined with fire brick from the floor line of the boiler room basement to that of the boiler room.

All of the boilers are joined to a common sheet metal breeching which, through a 6 by 14½-ft. opening, connects with a 225-ft. Custodis stack having an internal diameter of 16½ ft. at the base and 13 ft. at the top. Natural draft is used in connection with the wood-burning boilers while the coal-burning units operate on forced draft supplied by either one or both of two turbine-driven blowers, each having a capacity of 60,000 cu. ft. of air per minute when working against a pressure of

6 in. of water at a speed of 1185 r.p.m. The pressure ordinarily carried is about 3 in. of water.

Four steam-operated pumps, each 10 by 16 by 20 in., are used for the handling of the returns from the heating system, the dry kilns, pumps and other steam-operated devices, which, together with a small amount of make-up, is delivered to a feed-water heater of the open type. From here it is automatically fed to the boilers, three 300-gal. per minute centrifugal pumps each driven by an 85-hp. steam turbine having been installed for the purpose. These pumping units are shown in Fig. 6.

Ordinarily the boilers are operated at from 150 to 200 per cent of rated capacity. Steam is generated at 150 lb. gage and through the medium of 7-in. boiler leads is delivered to a 14-in. header which, in turn, connects with the turbines through 7-in. leads and with the air compressors through 4-in. leads. Each boiler is provided with an individual flow meter, thus allowing an accurate check being maintained on the performance of the unit.

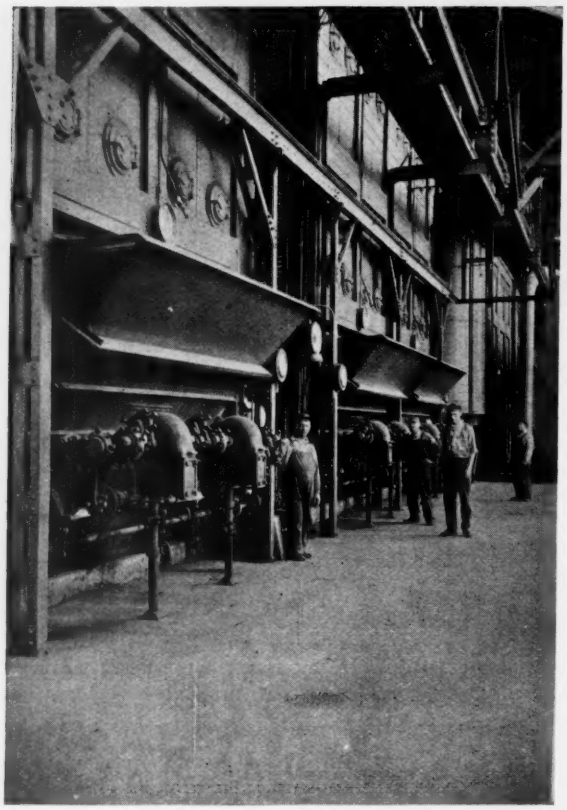


FIG. 4. THE COAL-FIRED BOILERS AND SOME OF THE BOYS WHO OPERATE THEM

Turbine-Room Equipment

Two 1000-kw. 60-cycle, 2300-v. three-phase noncondensing turbo-generating sets, two two-stage steam-driven air compressors each of a rated capacity of 1000 cu. ft. of free air per minute, the boiler feed pumps, two motor generator sets and the switchboard comprise the main turbine-room equipment. The air compressors installed are for the operation of pneumatic tools and paint and enamel sprayers in the finishing departments, while the motor generator sets are installed as a means to provide direct current for various purposes.

Electric Energy Distribution

As previously stated, the installed generator capacity is but 2000 kw., while the maximum demand for electric energy at times is in excess of 10,000 kw. In order, therefore, to insure a continuous supply when the requirements are greater than the amount capable of being generated and to maintain a maximum degree of economy and plant efficiency at such times as when the factory load is less than that capable of being delivered by the machines, a permanent connection has been established between the bus bars and the lines of the Union Electric Light and Power Co. Thus, when the factory load exceeds 2000 kw. the balance is at once taken over by the public service company, while if the factory load drops below this amount the 13,200-v. lines are discon-

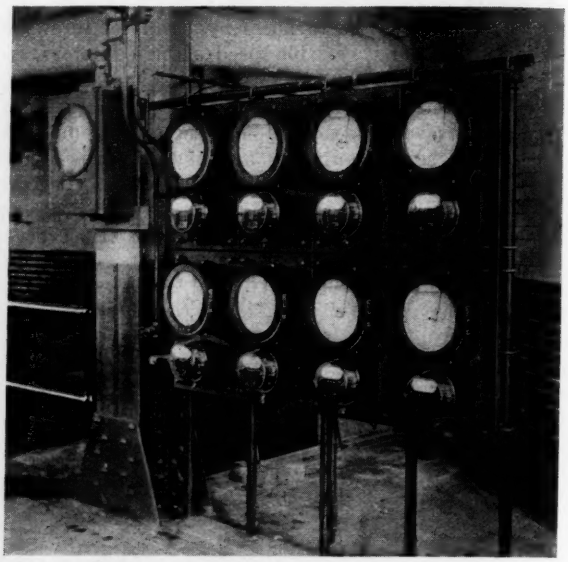


FIG. 5. THE TURBINE ROOM GAGE BOARD

FIG. 6. THE THREE BOILER FEED PUMPS ARE ALSO LOCATED IN THE TURBINE ROOM

nected by means of reverse-current relays. To provide this means of operation, two banks of transformers made up of three units, each rated at 1250 kv.a. and delta connected, have been installed in a separate building. The secondaries of these transformers are connected to the busses back of the main switchboard shown in Fig. 1.

Oil switches are employed for all high-tension switching operations. There are three main underground 2300-v. distribution circuits, one consisting of two 600,000 circular mil cables feeding the woodworking plant, three 500,000 circular mil lines for the Chevrolet plant and two 500,000 circular mil cables for the Buick assembly. At each of these points the voltage is reduced to serve the separate local light and power distribution circuits. In the woodworking or body-building plant are three 500-kv.a., 2300 to 440-v. delta-connected power transformers and three 100-kv.a., 2300 to 110-v. lighting transformers; in the Chevrolet assembly plant are two banks each of three 500-kv.a., 2300 to 440-v. power transformers and three 200-kv.a., 2300 to 110-220-v. lighting transformers; at the present time there are but five 550-kv.a., 2300 to 440-v. units installed at the Buick works.

Due to the characteristics of the load carried, both load and power factors are, on an average, comparatively low. Ordinarily a load factor of about 40 per cent exists and while up to the present time no arrangement of machines or operating schedules has made possible any improvement, the installation of four 190-hp. synchronous motors operated with over-excited fields has brought about a decided betterment of power factor. Under normal conditions of operation, this averages about 95 per cent.

Induction and synchronous motors for machine operation, lighting units and enameling ovens in the Buick and Chevrolet assembly plants consume the bulk of the electric energy generated or purchased. The total connected motor load is 2800 hp. for the greater part made up of machines ranging in size from 2 to 15 hp., although, as already stated, there are installed four 190-hp. synchronous motors and one 200-hp. wound-rotor induction machine which operates the hog in the body-building or woodworking shop. The enameling ovens, of which there are 11 in the Chevrolet plant, require a total of 3500 kw. when working fully loaded. Regulation of current flow to the heating elements of these ovens is by means of Leeds-Northrup thermostats.

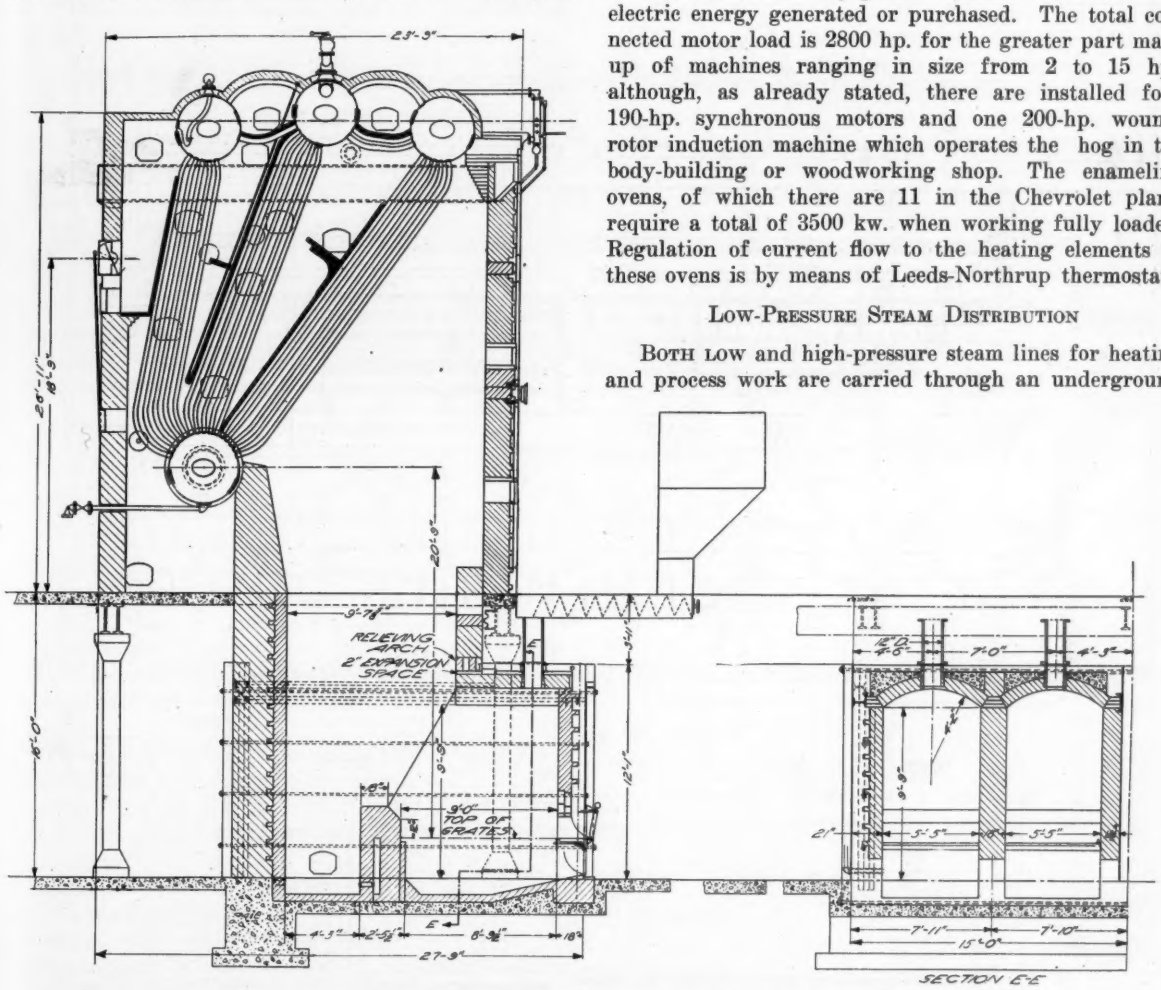


FIG. 7. SECTION THROUGH BOILER, WOOD-FIRED FURNACE AND SHAVINGS CONVEYOR

Low-Pressure Steam Distribution

Both low and high-pressure steam lines for heating and process work are carried through an underground reinforced concrete tunnel having sectional dimensions of 6 by 7 ft. and a total length of 350 ft. The steam exhausted by the turbines is that ordinarily used for heating and is transmitted through a 24-in. header to the body-building plant at which point are two 16-in. branch headers; at the other end of the tunnel are two 18-in. branches serving the Buick and Chevrolet plants. Each branch line is equipped with an indicating, recording and integrating steam-flow meter and in the event the steam available from the turbines should be insufficient to meet the demand the supply to the system may be augmented by live steam through a reducing valve installed for the purpose.

The regular high-pressure steam line which has a

diameter of 6 in. throughout its length is employed primarily for serving the enameling ovens in the assembly plants and a number of hydraulic pumps located in the woodworking shops.

The Dry Kilns

Much of the steam generated at the boiler plant is utilized at low pressure for the operation of the dry kilns. Of these, there are 21 each of the humidity controlled compartment type 18 ft. 11 in. wide, 84 ft. long and 12 ft. high, housed in a brick building carried on concrete footings and fitted with a roof of tile and concrete slab. Three rows of 35-lb. rails have been provided for each kiln which, together with the steam piping, are supported by steel post foundations.

The general construction of these kilns is shown in Fig. 8 and, as may be seen, each contains two separate heating and ventilating plants. For the introduction of fresh air galvanized iron ducts 12 by 36 in. and fitted with volume regulating dampers at the entrance in the operating pits and 1-in. outlets with about 2-ft. spacings are used. Six 6 by 12 by 12-in. tile ducts connecting with brick concrete-capped chimneys and equipped with three 10 by 12-in. dampers are built integral with the 13-in. brick party wall separating the various compartments. The operating pits of which there are two, each extending the entire length of the structure, are of reinforced concrete with inside dimensions of 6 by 6½ ft.

Carried along the interior of each operating pit are the two sources of steam supply, one a 10-in. exhaust main and the other a 4-in. submain, either one or both of which through manipulation of the proper valves can serve the heating units. There are six of these made up of approximately 15,000 lineal feet of 1-in. piping for each of the two plants contained in every kiln. Temperature control is by means of automatic regulators while vacuum drain traps care for the discharge of the condensate to the 6-in. vacuum return line.

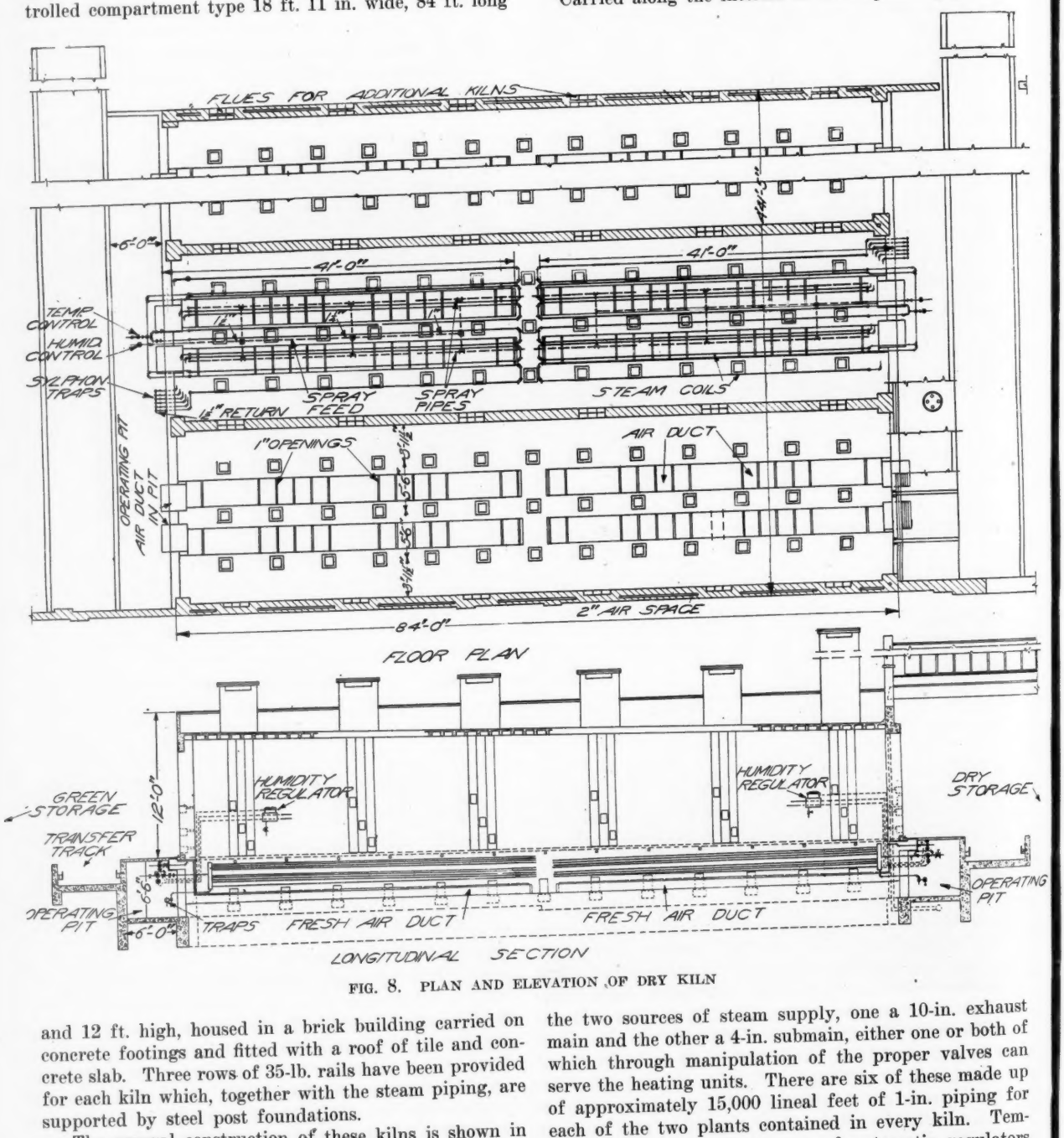


FIG. 8. PLAN AND ELEVATION OF DRY KILN

Two steam spray humidifying systems of the H type and built up of 1-in. perforated pipe with ½-in. cross connections have been installed in each kiln. Automatic regulators are employed to control the degree of humidity desired.

Upon delivery to the plant, the lumber is loaded directly onto the dry kiln trucks, hydraulic lowerators being employed in this work to enable the piling of the lumber to a maximum height with a minimum amount of labor. The trucks are then brought up to grade, moved onto the green storage tracks and placed in front of the kilns to which they are assigned and to which they are delivered in batch. After drying they are again advanced to the dry storage rooms. These dry storage rooms have a capacity somewhat in excess of the dry kilns and permit, in the gross, a considerable surplus of dry material ahead of the mill.

Hydraulic lifts are again employed in unloading the lumber at the surfacers. Here it is reloaded without sticks in a dead pile in trucks and run on rails to the cut-off saws where lifts are used a third time in final unloading.

A number of electric-driven power transfer cars are employed in the operation. These cars are equipped with drums, cables and transmissions enabling the operators to move cars of loaded lumber with power.

For Fire Protection

In spite of the fact that all of the buildings comprising the works of the St. Louis Manufacturing Corp. Division of the General Motors Co. are throughout practically fireproof, nothing has been left undone to provide effectively to control and subdue any fire which may occur either within the structures or on the surrounding grounds. These precautions have undoubtedly been found necessary because of the large quantities of combustible and inflammable material handled in some of the buildings, particularly the body-building and paint shops.

General layout of the underground fire lines and connecting sources of supply are well shown in Fig. 9. For immediate service, a 20 by 12 by 16-in. Underwriters' fire pump capable of serving six 1⅛-in. smooth-bore hose nozzles when operating at a rated speed of 120 strokes per minute has been provided and may, if necessary, be augmented by either one or both of two 1000-gal.-per-minute centrifugal pumps each driven by and direct-connected to a 100-hp., 2300-v. alternating-current motor. These pumps, which are indicated in Fig. 9, are located in a separate building but a short distance from the power house, draw their water from an open concrete reservoir having a capacity of 410,000 gal. or sufficient to allow operation of the pumps at maximum capacity for a period of 2 hr. City water may also be used for fire-fighting purposes. Should the pump pressure fall below that of the city mains, water from these is automatically cut into the fire lines and, as a further precaution in the event of the failure of either one or both of the other two sources of supply additional water may be secured for a 100,000-gal. elevated steel tank which will provide a ground pressure of approximately 50 lb.

The underground distribution system is made up of about 12,000 ft. of various sized lines connecting with and serving 24 fire plugs, 30 post indicator valves, 20 underground stop valves, 2 city taps, and 3 steam connections. Ten-inch mains serve the local headers which, in practically every case, are 8 in. in diameter; the branch leads are 6 in. These connect with the sprinkler systems proper (all of which are of the wet type equipped with Grinnell heads on 9 ft. spacings) post indicator valves and alarm valves.

In all about 10,000 sprinkler heads are installed. Those used in the kilns are designed for release at 212 and 286 deg. F., depending upon their location, while all others, except when placed under glass skylights, are for 155 deg. F. release. The temperature of release for the skylight heads is 212 deg. F.

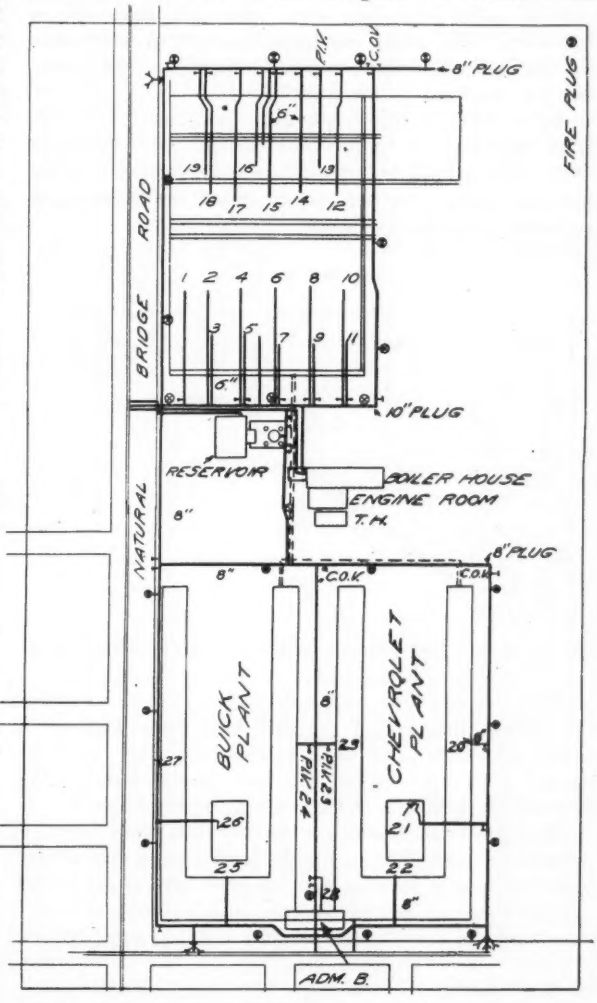


FIG. 9. UNDERGROUND FIRE LINES AT PLANT OF ST. LOUIS MANUFACTURING CORPORATION

Although these works of the St. Louis Manufacturing Corp. are now in operation they are not according to plans complete and considerable construction work remains unfinished. Design and building has been under the supervision of the Du Pont Engineering Co.

The generation, distribution and proper utilization of power is in charge of J. Underwood, whose assistance and co-operation has rendered possible the preparation of this article.

Using the Engineer's Level

PRACTICAL PROBLEMS IN THE POWER PLANT WHICH INVOLVE THE USE OF THE LEVEL. BY CHARLES L. HUBBARD

IN Fig. 1, a storage tank, holding 12,000 gal., is supported at such an elevation that the surface of the water is 60 ft. above the ground level when the tank is full. The supply is to be raised from the river below, and the pump is to be started and the tank refilled whenever the water level falls 4 ft. below the maximum or high level. The pump and pipe line are to be of such size that working under normal conditions, the entire tank may be filled in one hour.

An electrically driven pump is to be used, the combined efficiency of motor and pump being taken as $0.90 \times 0.70 = 0.63$, length of pipe line 1000 ft. What electrical energy, in horsepower, must be delivered to the motor when in operation?

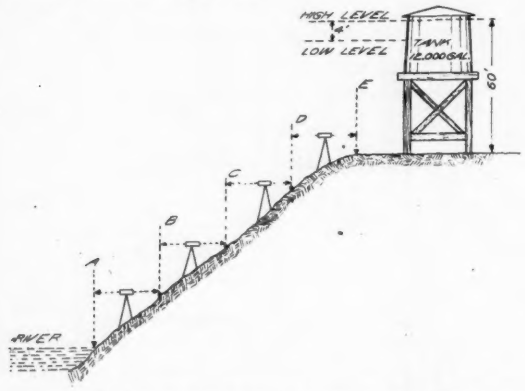


FIG. 1. USING LEVEL FOR FINDING DIFFERENCE IN ELEVATION

Here we have all of the necessary data for making the computation except the difference in elevation between the surface of the water in the river and the ground level upon which the tank trestle stands, that is, between station A and station E, in the diagram.

The first step, therefore, is to run a level between these two points, setting up the instruments and taking sights as shown in Fig. 1. Suppose further, that the various readings are as follows:

Station	Back Sight	Fore Sight
A	10	
B	11	2
C	12	1
D	9	2
E		3
Sum	42	8

which gives a difference in elevation of $42 - 8 = 34$ ft.

The average height during the pumping period will be 58 ft., making a total lift of $34 + 58 = 92$ ft. To this must be added the friction of the pipe, reduced to equivalent feet "head" or lift. The rate of pumping, to fill the tank in one hour, will be $12{,}000 \div 60 = 200$ gal. per min. The frictional resistance or "head" for a given volume of water, and length of run, will vary with the diameter of pipe, and a compromise must be made between higher cost of operation with a smaller pipe and greater cost of installation for a larger one. Referring to a table for the flow of water through pipes of different size, we find that for 200 gal. per min. and 1000 ft. run, a 4-in. pipe will give a "friction head" of 44 ft. and a 5-in. pipe one of 15 ft., making a difference in the lift of $44 - 15 = 29$ ft.; 200 gal. of water weigh $200 \times 8\,3 = 1660$ lb., so that a difference in lift of this amount would add $1660 \times 29 = 48{,}140$ ft.-lb. per min. to the work of pumping, or $48{,}140 \div 33{,}000 = 1\,5$ hp. (nearly).

If large quantities of water were required for industrial purposes so that the pump must be run more or less continuously, it would probably be more economical to install the larger pipe and thus reduce the operating expense; but if the volume of water actually used was small, and the pump was held in reserve for fire purposes, the cost of the added power required for pumping would be more than offset by the saving made by installing the smaller pipe.

In the present case, we will assume that the smaller pipe is to be used and that the tank is largely for emergency purposes. Under this condition, we have a total effective lift of $92 + 44 = 136$ ft., making the power for pumping under the assumed conditions, $\frac{1660 \times 136}{33{,}000} = 6.8$, or 7 hp. in even numbers. With a combined pump and motor efficiency of 0.63, the electrical input to the motor will be $\frac{7}{0.63} = 11$ hp.

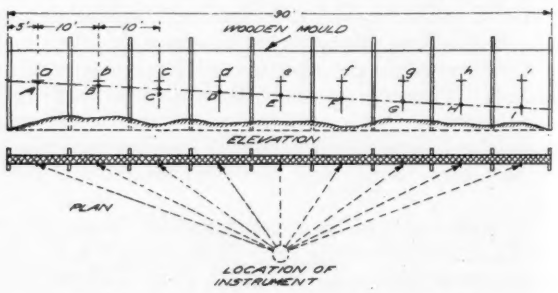


FIG. 2. ESTABLISHING GRADE OF DRAIN PIPE

GRADING DRAINAGE AND RETURN PIPES

IN FIG. 2, we have an example of laying out the grade for a drainage or return pipe in the basement of a building.

Let the elevation represent the wooden mold for a concrete basement wall, along which a drainage pipe is to be carried, having a uniform downward grade of 6 in. in 10 ft. The door of the basement is not yet fully excavated and the top of the woodwork is not sufficiently even to take accurate measurements from. It is desired to insert iron bolts for hangers in the mold before the concrete is poured, and these must necessarily be set true to grade.

Problems of this kind are easily solved by means of an engineer's level, as follows: Set up the instru-

ment 15 or 20 ft. from the wall, and approximately at the center, as shown in the plan. If the hangers are to be spaced on 10-ft. centers, draw vertical lines on the wall, as a, b, c, d, etc., 10 ft. apart, starting with the desired location of the first hanger. Take a sight through the telescope on line a and let the assistant mark where the horizontal cross hair intersects the vertical line. Swing the telescope on its spindle and take a sight on b, marking the intersection of the horizontal hair as before. In like manner, take a sight on each vertical line from a to i, inclusive, marking the intersections as shown on the drawing. The points of intersection, so marked, will all evidently be at the same height or elevation and on vertical lines passing through the various hanger locations.

Suppose the intersecting line on a is at the exact height it is desired to place the first hanger; then mark this "A." If the required grade is 6 in. in 10 ft., measure down 6 in. from the intersection on b and locate B, the position of the bolt for the second hanger. On c measure down 12 in., on e 18 in., and so on for each successive hanger, increasing the distance 6 in. over that of the preceding hanger, from the intersecting mark on the vertical line.

After all of the hangers have been located, holes are bored through the mold and bolts or studs driven through so as to project into the concrete the required distance after it is poured. Sometimes wooden plugs are used, which may be withdrawn so that anchor bolts may be inserted. It is not likely in any case that the height of the instrument will correspond exactly with that desired for the first hanger. In this case, mark the height of the intersections of the horizontal cross as already described. Locate the proper elevation of the first hanger on vertical line a, either by measurement from some base mark on the building, or by means of the level, taking a back sight on the base mark and a foresight on line a and computing the distance from the first intersecting line to the hanger location. After the first hanger is located, it is a simple matter to mark the positions of the others upon the vertical line.

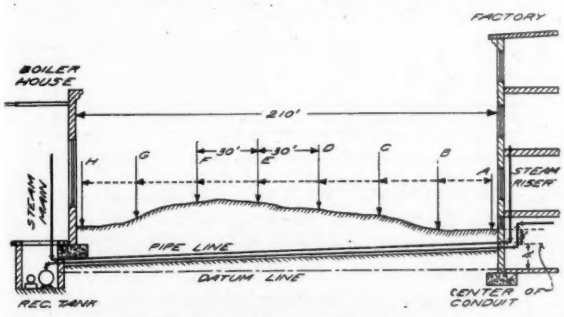


FIG. 3.—PROBLEM IN EXCAVATING

The method employed for grading return pipes from heating systems is exactly the same in principle, although the actual pitch will be less and the method of support different in many cases.

Excavation of Trenches for Pipe Lines

Let a factory building and boiler house be located, say, 210 ft. apart, with uneven ground between them as shown in Fig. 3. It is desired to carry steam and return lines in a tile conduit, as indicated, these having a uniform grade of 1 in. in 10 ft. toward the boiler room. The center line of the conduit is to be 3 ft. below the surface just outside the factory wall, at station A, and 4 ft. above the basement floor. The bottom of the trench is be excavated to a depth of 1 ft. below the center line of the conduit. The problem is to find the depth of excavation at points along the trench, 30 ft. apart, as indicated by the stations A, B, C, D, E, F, G and H.

In work of this kind, all elevations are referred to a common base or "datum line," which is an imaginary line, drawn through the lowest point of the excavation or below it. In the present problem, we will assume this to be on the level with the basement floor of the factory, as shown in Fig. 3; that is, 4 ft. below the centerline of the conduit and $4 + 3 = 7$ ft. below the ground surface at the factory wall.

TABLE I. READINGS AND CALCULATED RESULTS OF EXCAVATION PROBLEM

1	2	3	4	5	6	7	8
Station Letter	Distance to next Station—Feet	Back Sight—Feet	Fore Sight—Feet	Change—Feet	Height above datum—Feet	Bottom of trench above datum—Feet and Inches	Depth of trench—Feet and Inches
A		8			7	3-0	4-0
B	30		8	0	7	2-9	4-3
C	30		6	2	9	2-6	6-6
D	30		5	3	10	2-3	7-9
E	30		3	5	12	2-0	10-0
F	30		3	5	12	1-9	10-3
G	30		6	2	9	1-6	7-6
H	30		7	1	8	1-3	6-9

First measure off and mark stations 30 ft. apart, and in direct line between the two ends of the conduit, as shown by A, B, C, etc. Set up the instrument at some point from which each station is plainly visible. Take a back sight on station A and fore sights on the remaining stations, as indicated by the arrow heads on the dotted line passing through them. Suppose, in the example, these readings were as given in columns 3 and 4 of Table I. Column 5, headed "Change" gives the change in elevation of each station as compared with the first, upon which the back sight was taken, and is found by subtracting the corresponding fore sight from back site taken on A. Column 6 gives the height of each station above the datum line. Starting with A, the height above the datum line is 7 ft., that is, 4 ft. to the center of the conduit, and 3 ft. from here to the surface of the ground, as previously stated. As there is no change in elevation between A and B the height above datum is the same as at A. At C the ground rises 2 ft. above that at A, so the height above datum becomes $7 + 2 = 9$ ft. and so on for the other stations; that is, the height above datum at each station is found by adding the corresponding "Change" to the height of station A above datum.

The bottom of the trench was assumed as 1 ft. below the center-line of the conduit; hence, at station A, this would be 4 — 1 = 3 ft. above datum. The downward

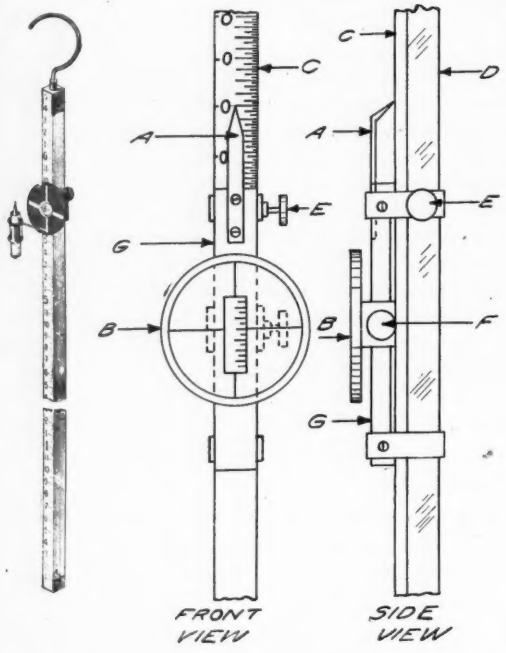


FIG. 4 FIG. 5

FIG. 4. LEVELING ROD FOR SHAFTING

FIG. 5. DETAILS OF ROD READILY ADJUSTED TO SHAFT OF VARYING DIAMETER

pitch toward the boiler house is to be 1 in. in 10 ft., which means a 3-in. drop at each succeeding station, these being 30 ft. apart. Hence, starting with the bottom of the trench 3 ft. above the datum line at A, we must reduce it 3 in. at each station, from that at the preceding station, which gives the figures in column 7.

TABLE III. READINGS TAKEN ON SHAFT OF VARYING DIAMETER

1	2	3	4	5	6
Bearing	Diameter of Shaft - Inches	Base number Feet and Inches	Reading- Feet and Inches	Raise Shaft- Inches	Lower Shaft- Inches
A	1	5-8	5-8	0	0
B	1	5-8	5-8 1/4	1/4	
C	1 1/2	5-7 3/4	5-8 3/8	5/8	
D	1 1/2	5-7 3/4	5-8 1/2	3/4	
E	2	5-7 1/2	5-8	1/2	
F	1 1/2	5-7 3/4	5-7 1/4		1/2
G	1 1/2	5-7 3/4	5-7		3/4
H	1 1/2	5-7 7/8	5-7 1/2		3/8
I	1 1/2	5-7 7/8	5-7 3/4		1/8
J	1	5-8	5-8 1/4	1/4	

The depth of the trench is evidently the difference between the height of the station above the datum line and the bottom of the trench above the same line, and is found by subtracting the quantities in column 7 from those in column 6. Knowing the depth of the trench at each station, it is a comparatively easy matter to excavate so as to give the proper grade to the bottom. If the ground is quite uneven, the stations may be taken nearer together. The cubic yards of excavation in any given case are easily computed when the depths at the different stations are known, as it is possible to approximate the average depth from these, which, multiplied by the width and length will give the volume of earth to be removed.

Shafting Alinement

Another important use of the engineer's level is in connection with the alinement of long lines of shafting, both for old and new work. The methods employed are much the same in principle as those described for grading pipe lines, except in this case, the line must be exactly horizontal instead of having a downward pitch. A common form of leveling rod for this purpose is shown in Fig. 4, and is similar to those previously described except that it is hung over the shaft by means of a hook at the top instead of being supported from the bottom. Readings are taken through an opening in a sliding target, the latter being provided with a small wax candle when the room is too dark to read the scale easily.

In using a rod of this kind, the level is set up at one side and approximately midway of the shaft, at such a position that the target may be seen when the rod is hung from a point near each bearing. Starting at one end, the rod is hooked over the shafting and the target moved up or down until it is exactly on a line with the horizontal cross hair. The reading is now taken, which gives the index or base number with which all other readings must be compared. Suppose this to be 5 ft. 8 in., as in Fig. 4. Next move the rod to a point close to the second hanger and take a sight from the same instrument position, moving the target as before,

TABLE II. READINGS TAKEN ON SHAFT OF UNIFORM SIZE

TABLE IV. READINGS TAKEN WHEN ADJUSTING SHAFT BEARINGS FOR SIDEWAYS MOVEMENT

Table IV

1	2	3
Bearing	Move to Right- Inches	Move to Left- Inches
A	0	0
B		1
C		1/2
D	1 1/4	
E	1/2	
F	5/8	
G		3/8
H	0	0

Table II

1	2	3	4	5
Bearing	Base number- Feet and Inches	Reading- Feet and Inches	Raise Shaft- Inches	Lower Shaft- Inches
A	5-8	5-8	0	0
B	5-8	5-8 1/4	1/4	
C	5-8	5-8 5/8	5/8	
D	5-8	5-8 1/4	1/4	
E	5-8	5-8	0	0
F	5-8	5-7 1/2		1/2
G	5-8	5-7 1/4		1/4
H				

until it comes in line with the horizontal cross hair. Suppose the reading this time is 5 ft. 8½ in. As the target must necessarily be at the same height as before, this evidently means that the rod is ½ in. lower; and as the rod is hung from the top of the shaft, this also must be ½ in. lower than at the first bearing. Readings are taken in this manner close to each bearing, which should be given an index letter, and a record made in a note book. This would appear as in column 3 of Table II. The amount which the shaft must be raised or lowered at each bearing to bring it to the same level as at A, is the difference between the "base number" and the reading taken at that bearing.

With a rod graduated like that in Fig. 4, the shaft must be raised when the reading is greater than the base number, and lowered when it is less. When the shaft is the same size throughout its entire length, the base number remains constant for all stations or bearings, with a rod like Fig. 4. If the diameter changes,

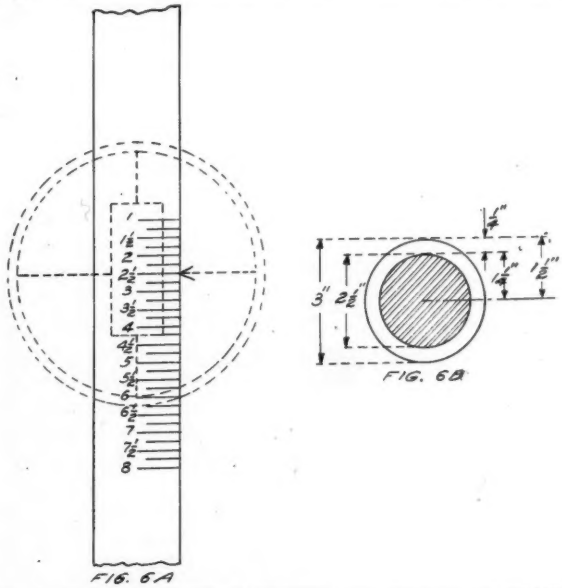


FIG. 6. ENLARGED VIEW OF TARGET AND SECTION OF SHAFT WITH TWO DIAMETERS

which is usually the case, a new base number must be taken, equal to the preceding one minus one-half the increase in shaft diameter, or plus one-half the decrease in diameter, whichever the case may be. This is evident because the leveling rod is hung from the top of the shaft, so that it would be raised with an increase in diameter even though the center of the shaft remained at the same level. Table III gives readings and corrections where the diameter of the shaft changes. Rods with compensating clamps for attaching to the shaft may be had which require no correction for changes in diameter, and the same base number may be used throughout the line regardless of changes in diameter.

A rod which is easily adjusted to shafts of different size, and which gives the change in elevation directly, without the use of a base number, is shown in Fig. 5. This rod is made in two parts: D, to which the hook for hanging on the shaft is attached, and C, carrying the graduations, which slides on the front of D, and which can be clamped in any position by a thumb screw, not shown in the drawing. G is a carriage, sliding on the rod, carrying a pointer, A, a target, B, and held in place by clamp, E.

To use the rod for a shaft of uniform diameter, unclamp E, after hanging the hook over the shaft, and slide the carriage, G, up or down until the center of the target, B, comes exactly in line with the horizontal cross hair in the telescope, and clamp in place. Next unclamp the front of the rod, C, and move it until the pointer, A, comes exactly on the nearest 0 line, as shown in the front view, and clamp. The graduations are in inches and sixteenths, and the 0 lines are 3 in. apart, which will take care of a shaft 3 in. out of level both up and down from a given starting point. (This may be made any other distance if a greater range is desired.)

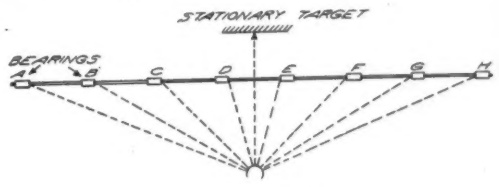


FIG. 7. INSTRUMENT POSITION FOR LEVELING SHAFT

These adjustments being made, with the rod hanging on the shaft near the first bearing. It is then moved to a point near the second bearing, when E is unclamped and the carriage, G, moved up or down until the center of target B again coincides with the cross hair of the telescope. The distance of the pointer above or below the 0 mark upon which it was first set will indicate the distance the shaft is out of level at the given position. If the pointer is above the 0 mark, the shaft should be raised, and if below, the shaft should be lowered. When the diameter of the shaft varies at different points, thumbscrew F. which allows the target B to slide on carriage G, is made use of. An enlarged view of this target, with the scale on G beneath it is shown in Fig. 6A. The figures represent the diameter of the shaft and run from 1 to 8 in. with quarter-inch divisions.

FIG. 8. INSTRUMENT POSITION FOR ALINING SHAFT IN VERTICAL PLANE

When using, unclamp F and set the horizontal pointer on the center line of the target on the figure corresponding with the diameter of the shaft at the starting point (2½ in. in Fig. 6), then proceed exactly as already described for a shaft of uniform size. Whenever the diameter of the shaft changes, simply set the target to correspond with the new diameter, and go on as before. Setting the target in this way makes all necessary corrections without interfering in any way with the readings given by pointer. A.

The principle upon which this latter device operates is illustrated in Fig. 6B. Suppose the rod is hung from the top of a 2½-in. shaft, as shown by the shaded circle in the drawing; the hook (not shown) will be 1¼ in. from the center, or a distance equal to the radius of the shaft. If now the diameter increases to 3 in.,

the hook and rod will be raised ¼ in., although the center of the shaft is at the same height as before; hence, in order to keep the target at a uniform distance from the shaft center, it must be lowered ¼ in. to offset the raising of the hook. By inspecting Fig. 6, we see that bringing the pointer on the target down to figure 3 on the scale will bring this about. The devices shown thus far are for true level. As a matter of fact, a shaft must be in a vertical plane also as it may often be out of true sidewise, although it is not so likely to be thrown out of alinement in this direction by settling of the building. The general method of setting up the instrument and taking the sight for leveling a shaft is shown in plan in Fig. 7. In order to guard against any possible disturbance of the instrument during the process it is well to mark a stationary target on the wall and take frequent sights upon it to make sure that the height of the instrument remains constant.

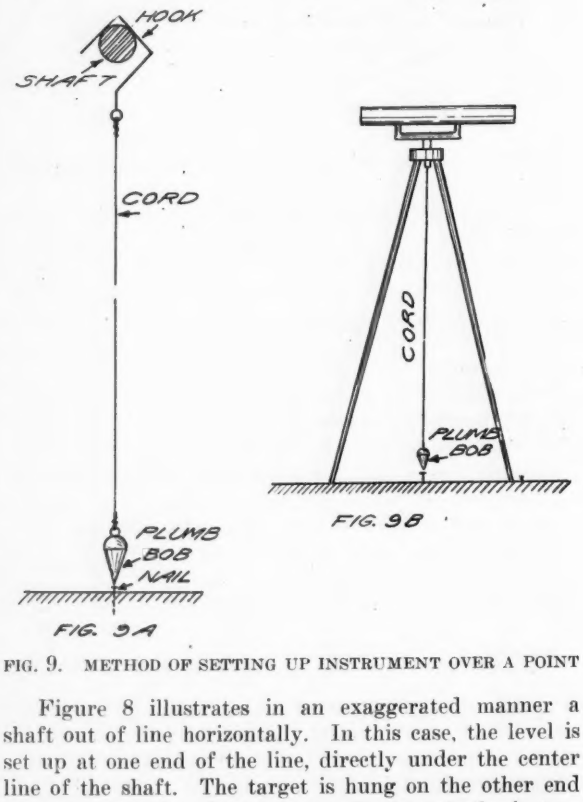


FIG. 9. METHOD OF SETTING UP INSTRUMENT OVER A POINT

Figure 8 illustrates in an exaggerated manner a shaft out of line horizontally. In this case, the level is set up at one end of the line, directly under the center line of the shaft. The target is hung on the other end of the shaft and a sight taken on it through the instrument. The line of vision is represented by the dotted line, and the center of the shaft at each bearing must be made to coincide with the vertical cross hair of the telescope. If both ends of the shaft extend close to the building wall, the instrument and target may be set just inside the end bearings instead of beyond them.

The method of setting up the instrument exactly beneath the center of the shaft is illustrated in Figs. 9A and 9B. Make a hook of stout wire, of the form shown in Fig. 9A, with the eyelet for attaching the cord directly in line with the inverted V at the top. Attach a cord and plumb-bob, letting the latter down until the point just touches the floor, and carefully mark the spot, first with a scratch awl or pencil and then by driving in a small wire brad or nail. With this arrangement, the point of the plumb-bob will be directly below the center of the shaft. Remove the hook, etc., and set up the instrument so that a plumb-bob attached to this will hang with its point, exactly over the nail, as shown in Fig. 9B. When in this position, the center of the instrument will be directly under the center of the shaft, and when sighted on a cord or target suspended from the other end, as in Fig. 8, the line of vision will mark a straight line between the end bearings, to which the center of the shaft must be brought at each intermediate bearing.

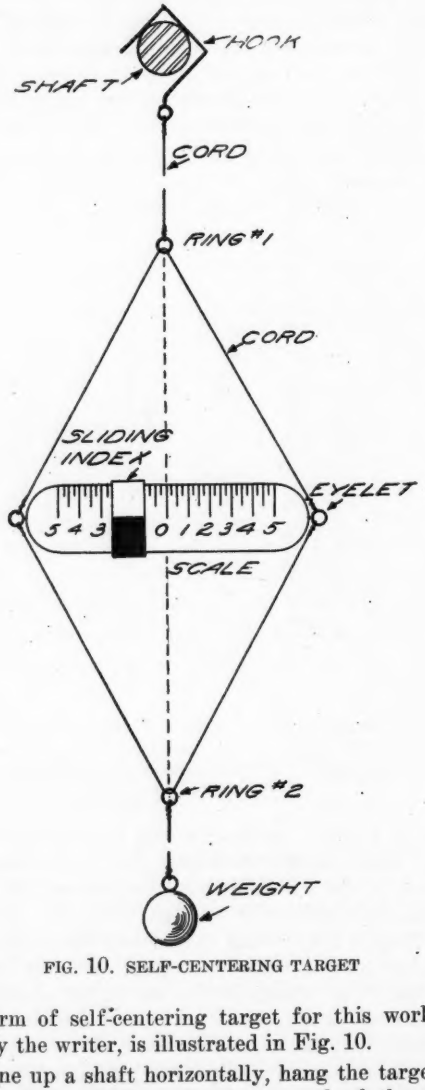


FIG. 10. SELF-CENTERING TARGET

A form of self-centering target for this work, suggested by the writer, is illustrated in Fig. 10.

To line up a shaft horizontally, hang the target over one end of the shaft, and set one end of the sliding index on the 0 mark. Set up the instrument at the other end directly under the center of the shaft. Adjust the length of the cord attached to the hook (see Fig. 10.) so that the scale of the target comes approximately at the center of the field of the telescope, next bring the vertical cross hair exactly in line with the edge of the sliding index which is set on the 0 mark, and clamp the spindle of the telescope so it cannot turn from this position. This gives a range which is a true line between

the ends of the shaft as shown by the dotted line in Fig. 8. Now having the target at B, Fig. 8, move the sliding index so that the vertical cross hair again coincides with the edge, and read the scale. The distance from the 0 mark will be the amount the shaft is out of alinement. The reading shown in Fig. 10 indicates that the shaft should be moved 1 in. to the left.

If when taking a sight with target in a new position, the vertical hair in the telescope comes at the right of the 0 mark, move the sliding index over so as to read from the left-hand edge. If the hair comes at the left of 0, move the index so as to read from the right-hand edge, as in Fig. 10. This uncovers the scale so it is more easily read. The notes for work of this kind are kept as shown in Table IV.

There will be no difficulty in determining which way the shaft should be moved if it is remembered that 0 on the scale indicates the center of the shaft as it is, and the reading through the telescope the true position. The various devices shown are simply representative; others operating on the same general principles may be used if desired.

Preparing Boilers for Inspection

METHODS TO EMPLOY FOR RAPID COOLING; REMOVING VAPOR FROM DRUMS; PRECAUTIONS WITH LEAKY STOP VALVES. BY EDWARD RUTLEDGE

BOILER inspection, never a pleasant task, is often made more difficult by well intended but misdirected efforts of the attendants. The preparation of the boiler is usually left to the men in the fire-room without any supervision or directions of the manner in which they shall proceed. If the boilers are to be off the line for only a short time, the men will, in an attempt to cool them as much as possible, throw open all the doors in the setting as soon as the fires are drawn.

This is the condition that the inspector often finds when he enters a boiler room—it is the rule rather than the exception. The men do not seem to realize that with the doors wide open the air circulation is almost negligible, and there is only a slow loss of heat by radiation. They are not inclined to reason out little problems of this nature for themselves, but hardly more than a suggestion is necessary to show them that a strong current of air will carry away more heat in a few hours than would radiate off in a night.

More than once the writer has found a boiler seemingly unbearably hot. The attendant is much concerned over his lack of success; the fire was burnt out early the previous afternoon and the doors in the setting opened. The night watchman had opened the blowoff shortly after midnight; early this morning, the plates had been knocked in and a stream of cold water had been going into the boiler since that time. He honestly thinks he has done everything possible to cool that boiler. He has, as a matter of fact, done about everything he should not do; but to save time, and for other reasons, we do not tell him—we show him.

First, that stream of cold water is shut off. Of all contemptible treatments, the water cure deserves first mention. In a hot boiler, not only is it apt to set up severe contraction strains, but the vapor caused by its striking the warm plates makes a moist, sticky, enervating atmosphere that very quickly saps the good nature out of anybody who works in it.

In passing, it may be said that next to water in a warm boiler, water sprayed into a cold boiler is the next least desirable. It leaves the surface wet and dark, making it difficult to discern what would be readily apparent in a dry boiler. It may even completely hide some condition at a place that can only be examined at long range.

So much for cussing the water cure; if it takes root, the effort will be one well spent. Now, take the fireman by the arm, as it were, and gently intimate that the doors in the setting, excepting the fire doors, should be closed and the main damper and flue damper opened wide.

In 30 min., unless conditions are unusually bad, the boiler can be entered and examined. It is not intended to give the impression that the boiler will be cool; a shell in a heavy setting of brick cannot be brought down to the temperature of the boiler room in 24 hr. or less. If, however, the draft is utilized as outlined, the boiler will be in very fair condition for inspection.

While the cleaning of the combustion chamber and gas passages is in progress, the draft will of course be checked. As soon as the cleaning is completed, the doors should be closed again and the dampers set so that the flow of air will continue.

Leaky stop valves are often a source of difficulty in cooling a boiler. Double stop valves offer a means of overcoming this, but even these are a disappointment unless both valves are closed and the drain valves between them opened. That little drain valve is so often overlooked; its only function is that which its name implies, to drain between the two stop valves. It is the attachment that makes the double stop valve arrangement worthwhile.

With only one stop valve between the boiler and the main, severe leakage by the valve is a source of real danger to one entering the boiler. It is a condition that often is not known to exist until the boiler is opened. The time is then too short to put the valve in proper condition and other means must be devised to overcome the difficulty. The simplest way, of course, is to shut off all steam from the main if conditions will permit. Usually steam must be kept on the main and it then may be necessary to blank between the boiler and leaky stop valve; or to remove a safety valve. In a drum boiler with two or more drums, a very effective expedient is to place an electric fan close to the manhole of one drum. The slight pressure caused by the air current will be sufficient to check the leakage into the drum and as long as the fan is in operation, the vapor will be forced into the other drum. The fan need not be started until a few moments before the drums are to be entered.

The essential points brought out have been to get the water out of the boiler to be inspected as soon as possible, to refrain from washing out until after in-

spection, to keep out vapor from leaky stop valves and to maintain an air current through the boiler every moment possible from the time the fire is drawn.

To this may be added the removal of manhole plates, handhole plates and tube caps. These should be knocked in as soon as the water is out. The manhole plates should not be allowed to drop into the boiler, to break off a feed pipe or surface blowpipe as is often the case. Back the nut off the bolt in the manhole plate until only about half of the nut remains on the stem. Standing so that the cloud of vapor that will issue may be avoided strike the plate a few sharp blows with a heavy hammer until the gasket joint is broken. Do not attempt to remove the plate at once, but leave it suspended in the hole until it has cooled sufficiently to handle.

Handhole plates and tube caps should be handled in the same manner. The interior of the boiler is thus vented from the earliest possible moment. With the air drawing through and the other essential points observed, the boiler will be in the best condition attainable, not only for the inspector, but for the men who are to remove the soot and ashes.

Standardizing boiler construction has, within the past few years, brought about better design, better material and better workmanship. Rules and codes cannot, however, safeguard boilers against the wear and tear of service other than to provide for the periodic inspection of the vessel.

Important, then, as is the work of the inspector, so, too, is the proper preparation for inspection. A man may struggle and squirm and wriggle through a hot boiler; he will do his best, but he is only human and his best under such harrowing conditions cannot equal his best when conditions are more favorable. Nor is he gifted with second sight to see through a cloud of dust or a heavy coating of soot.

Give, then, a little more consideration to the preparation for the boiler inspector. A few detail instructions to the man is often the only extra effort required, instructions which, if followed, will in many cases give better results and even lighten the labor involved.

Horizontally Baffled Boilers

Developing High Overload Capacities with Horizontally Baffled Boilers

MODERN industrial boiler plant practice at present shows a marked tendency toward the use of larger and more efficient units in order to avoid the labor troubles, shut-downs, and standby losses experienced with low capacity and uneconomical equipment. In some instances, this is achieved by rebuilding the boiler house, installing up-to-date high duty boilers, and by introducing the proper machinery for handling coal, ashes and feed water.

In one of the largest textile mills, for example, five 950-hp. horizontally baffled water-tube boilers and superheaters set with underfeed stokers have been installed, to replace seventeen 250-hp. and four 275-hp., a total of twenty-one fire-tube boilers equipped with hand-fired grates. The water-tube boilers have been in operation for about 2 yr. under conditions of unusually severe and continuous service and have fully demonstrated through satisfactory performance the advantages of units of this size and type. Whereas ten firemen, five water tenders, two repair men and one foreman were required formerly, the present force consists only of two men, one to watch the boilers and the other to operate a coal crane.

This article describes briefly a series of four tests conducted on one unit of installation to ascertain whether an arrangement of the horizontal baffling suitable for attaining high capacities would prejudice the efficiencies obtainable at lower ratings.

The tests were run under the usual working conditions prevailing in the plant in order to get results which would represent the commercial performance to be expected in industrial service from large stoker-fired boilers of this type. Nothing was "polished up" in order to get record-breaking results. At the time of the trial, the boiler tested had been in continuous service for 3½ mo.

All of the plant load, in excess of the capacity developed by the unit under test, was handled by three of the other boilers operated at moderate rating by the regular boiler room force.

The fuel burned was taken at random from the large tonnage in storage at the plant and comprising many

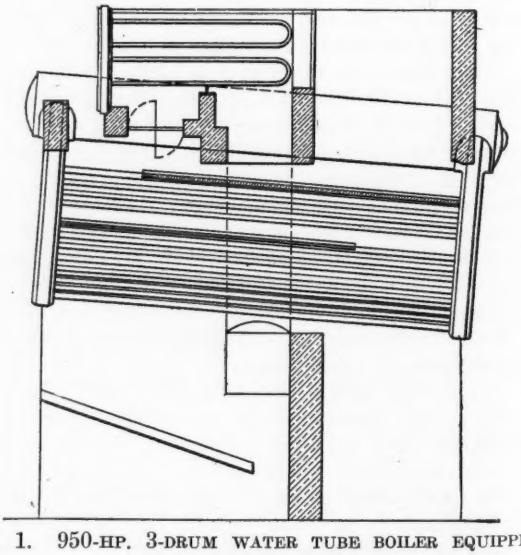


FIG. 1. 950-HP. 3-DRUM WATER TUBE BOILER EQUIPPED WITH SUPERHEATER

deliveries from various sources. The results of analysis indicated that this was only a fair grade of low-volatile Pennsylvania coal, typical in quality of the vast quantities of similar fuel delivered to the New England mills during the past 2 yr.

The boiler tested was a standard Heine horizontally baffled boiler set as shown in Fig. 1. The arrangement of

baffling should be particularly noted. Such modifications are often advisable if high efficiency is to be maintained with different furnace conditions resulting from a change of fuel or operation. The principal dimensions of the boiler are as follows:

No. of steam drums	3
Diameter of steam drums	42 in.
Length of steam drums	20 ft. 9 in.
No. of tubes	551
Diameter of tubes	3.5 in.
Length of tubes	18 ft.
Water heating surface	9500 sq. ft.
Superheating surface	633 sq. ft.
Grate surface, including dump grate	147.4 sq. ft.
Ratio of water heating surface to grate surface	64.5 to 1
No. of stoker retorts	10

A thorough examination of the boiler, superheater, setting and stoker was made before and after the tests were run. The boiler was found to be free of all leakage, and deposits of soot or slag on the heating surfaces. There was some scale in the tubes which increased in thickness from nothing in the upper tubes to 1/16 in. in the lower ones. The brickwork of the furnace, setting and superheater was in good condition. The baffling was intact and tight. The stoker was in excellent mechanical condition throughout the tests.

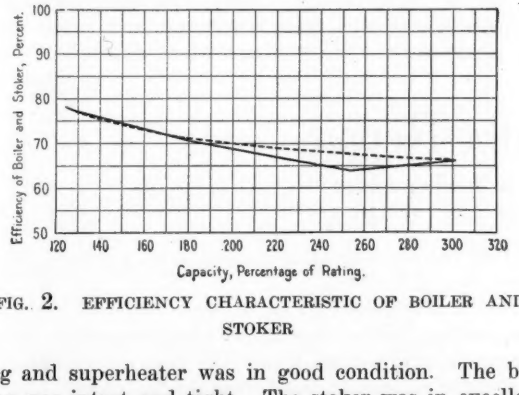


FIG. 2. EFFICIENCY CHARACTERISTIC OF BOILER AND STOKER

The method of conducting the boiler trials was that prescribed by the A. S. M. E. code. All instruments and scales were compared with standards. The calibration of the water measuring tanks was checked by independent observers.

The coal was weighed by a sealed scale carrying an overhead hopper of 2000 lb. capacity, from which it was transferred as required through a chute to the stoker hopper. The scale was provided with a self-registering beam. Duplicate tickets were made at each weighing. Coal analyses were made from carefully worked down samples of 500 lb. taken from the crushed coal during each test. All stoker siftings and samples were weighed back. The ash analyses were made on samples representing the entire quantity of refuse as weighed worked down in the usual manner.

Feed water was measured in three carefully calibrated tanks holding an aggregate of 9128 lb. of water at 130 deg. F. The test boiler was provided with an independent feed pump and piping. Hot and cold water were available at the measuring tanks enabling the close maintenance of the feed water temperature.

Every precaution was taken in the feed and blowoff piping to insure the measurement of all water entering the boiler and to guard against any leakage.

The coal consumed and water evaporated were determined for each hour of the test to obtain the approximate rating developed. The rating was also observed by means of an indicating flow meter.

Readings of pressure, temperature, draft, etc., were taken at 15-min. intervals. Analyses were made for CO_2, CO and O_2 in the furnace flue gases.

Fires were cleaned one hour prior to starting all tests. Especial care was exercised to duplicate the conditions of the fuel bed at the beginning and end of all trials.

Tubes were blown every 6 hr. during the 24-hr. test.

The complete data for each test are given in Table I. In judging the performance results obtained, several important factors should be considered. The coal burned was not a high grade selected fuel but had a fairly high ash content and produced a troublesome clinker at high rates of combustion. The results as obtained with this fuel should therefore be considered as most creditable.

SUMMARY OF DATA AND RESULTS

Date	Test 1. Sept. 30, 19 Oct. 1, 19	Test 2. Oct. 3, 4, 19	Test 3. Oct. 7, 19	Test 4. Oct. 10, 19
Duration, hr.	24	21	3	3
Steam pressure, gage	134.0	130.0	140.0	141.2
Superheat deg.	136.2	126.4	99.2	153.5
Feed temp., deg.	127	127	125.5	129
Flue temp., deg.	541	600	670.8	694
Pressure in wind box, in.	2.63	4.3	6.2	6.46
Draft in uptake, in.	.293	.75	1.18	1.25
Total coal fired, lb.	92,799	124,569	28,561	32,270
Per cent moisture in coal	2.89	1.61	2.33	2.56
Total water fed, lb.	825,605	1,032,301	209,391	243,208
Factor of evaporation	1.208	1.204	1.192	1.217
Coal fired per hr. lb.	3,867	5,931	9,520	10,757
Coal fired per retort per hr. lb.	386.7	593.1	952.0	1075.7
Dry coal per sq.ft. of grate surface per hr., lb.	25.47	39.6	63.1	73
Water evap. per hr., lb.	34,400	49,157	69,797	81 069
Equivalent evap. per hr.	41,555	59,185	83,198	98,661
Builders Rated horsepower	950	950	950	950
Boiler horsepower developed	1,205	1,716	2,411	2,858
Per cent rating, developed	126.8	180.6	253.8	300.8
Water evap. per lb. coal as fired	8.89	8.29	7.33	7.54
Equiv. evap. per lb. dry coal	11.07	10.14	8.95	9.41
B.t.u. per lb. dry coal	13,850	13,917	13,581	13,796
Per cent ash dry coal	10.91	10.54	12.23	11.19
Per cent combustible in ash	15.11	16.63	-----	-----
Combined efficiency	77.56	70.71	63.93	66.21

The uniformity of the test conditions was materially affected by the variable operation of the three other boilers in service, all supplying steam to a common system. The limitation of capacity performance was entirely due to the inability of the stoker to handle and dispose of the troublesome clinker produced.

The data show that high overload capacities can be developed with this type of boiler and arrangement of baffles. The efficiency characteristic of the boiler and stoker is drawn in Fig. 2. The point corresponding to test No. 3 is open to question, because the coal used contained more ash than the coal of the other tests. Since the resulting clinker interfered noticeably with the management of the fire at the high rating obtained, this may well account for the low efficiency of this test. The

dotted curve probably represents the true characteristic of the boiler when burning coal of the quality used as long as it can be worked through the stoker. The excess temperature of the gases from the boiler as affected by the rate of driving is given in Fig. 3. Figure 4 shows that the boiler starting from a banked fire can take up a

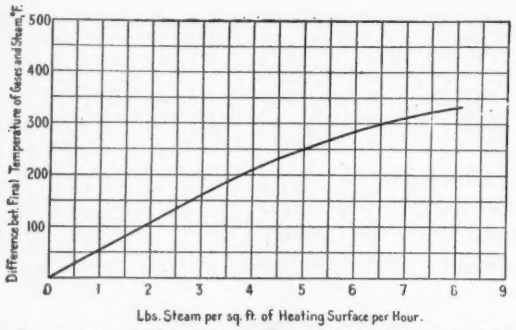

Difference bet. Final Temperature of Gases and Steam, °F.
500
400
300
200
100
0 1 2 3 4 5 6 7 8 9
Lbs. Steam per sq. ft. of Heating Surface per Hour.

FIG. 3. CURVE SHOWING EXCESS TEMPERATURE OF GASES FROM STEAM BOILER AS AFFECTED BY RATE OF DRIVING

300 per cent overload in 4 min. 23 sec. From the excellent performance of this boiler at high overloads—overloads which were limited only by the fusing of the clinker in the low and fair grades of the coal used—it would appear advisable to consider the desirability of using larger grate areas than is customary.

Results further establish that the arrangement of baffling which is especially suitable for obtaining maximum capacities does not affect adversely the efficiencies obtained at lower ratings. High overloads could have been readily maintained for indefinite periods if a higher grade fuel had been available.

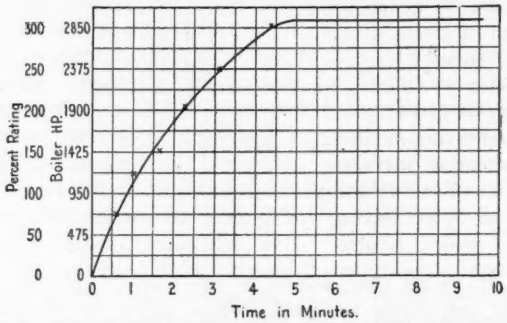


FIG. 4. CURVE SHOWING HOW RAPIDLY THE BOILER WILL TAKE UP A HEAVY OVERLOAD STARTING FROM A BANKED FIRE

The combustion results obtained were consistently good. The flue gas temperatures were not extreme considering the capacities developed. The condition of the heating surfaces after tests was found to be good with little accumulations of soot and with no deposits of slag.

Hydraulic Elevator Repair

How a Cast-Iron Flange Was Welded to the Casing in Position. By Geo. H. Wallace

IN A former article, the writer chronicled an accumulator runaway in which the offending piece of machinery chose an upward direction as the one of least resistance. In the present instance it is an elevator accident in which gravity played the leading part.

The elevator was of the direct-acting plunger type three-story lift with a maximum capacity of 25,000 lb. and was actuated by a 17-in. ram working in a cast-iron casing 22 in. outside diameter sunk in the ground. Pressure was obtained from a motor-driven triplex-geared pump with an air pressure reservoir between the pump and the elevator ram.

At the time the elevator was installed several years ago, the contractor miscalculated the depth of the well and when the several lengths of cast-iron casing were lowered into place it was found that they projected from the ground 2 ft. too far. The casing had the flanges cast on as shown by the dotted lines in Fig. 2. The proper method of rectifying the error would have been to cast a new length short enough to suit. Instead of doing that, however, the top length was taken to a lathe and cut off, and a pipe thread chased on. A flange was then threaded to suit and screwed on. Thus two threads of cast iron were screwed together. The joint gave more or less trouble from time to time, up until a short time before the accident, but on each occasion the flange was screwed farther on by means of improvised devices that would reach down into the hole.

On the day in question the elevator man noticed that he used more than three times the usual amount of water and that the elevator settled about 2 in. a minute when at rest at a given floor.

This was reported to the writer, who took steps to have new cup leather put in the regulating valve as the plunger packing did not leak. The next report was that the elevator refused to move from the first floor. Crawling down through a 9-in. opening beside the elevator to investigate, the operator was ordered to turn on the water. With the application of pressure, the massive stuffing-box with a 4-in. inlet pipe rose up about an inch and water at high pressure deluged most of the limited space around. Investigation showed that the flange had slipped off the casing.

Jacks, blocking, and men were passed down and the platform (with ram attached) was raised about 6 ft.—enough for head room. As the cement floor had on some previous occasion been broken away from the casing, it was only necessary to dig out the soil all around the casing to about 2 ft. below the break.

Figure 1 shows the relative location of the several parts and the devices used in making repairs. The water in the casing was pumped out to about the ground level; but as this was about on the level with the river near by, the soil was naturally thoroughly soaked and this required frequent attention with a pump.

Cutting a new thread was out of the question, as the thread was an odd size and besides it would not have been possible to put a portable die over the ram or to take the flange off and replace it with another. The welding foreman was called in and said he believed that

the flange could be welded. This was a ticklish proposition even under the most favorable conditions for preheating.

The stuffing-box was hoisted, the casing and flange were chipped off generously all around and the flange marked so that the stuffing-box would be in the proper location relative to the inlet pipe.

In the meantime, some pieces of old steel plate were punched out for grates so as to fit reasonably close to the casing. On top of this was placed a sheet iron ring as shown in Fig. 1, the whole resting on bricks. The space all around the casing was filled in with charcoal and lighted. Several air hoses supplied ample air for proper combustion.

In 4 hr. the casing and flange had been heated gradually to a dull red. Several thicknesses of ⅛-in. asbestos paper wrapped around the ram protected it nicely. Two expert welders completed the welding in less than 3 hr., piling the metal up above the top of the flange slightly as shown at A in Fig. 2.

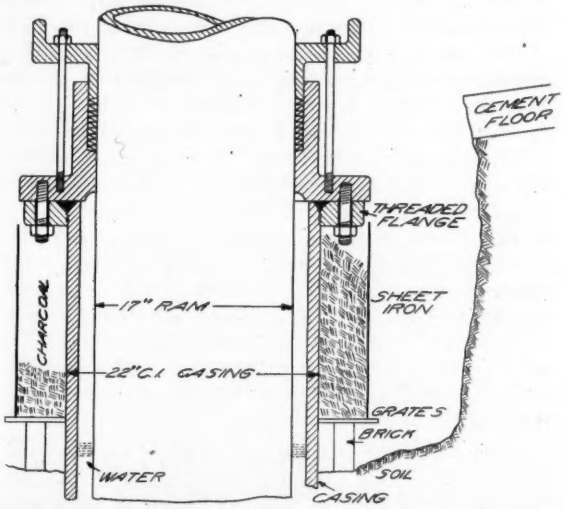


FIG. 1. SECTION THROUGH CASING, SHOWING IMPROVISED FURNACE FOR PREHEATING

The charcoal "bunkers" were then filled to the top again and the fire was allowed to cool gradually, one man staying on the job all night to "keep the fire up and the water down." This was one place where low water was absolutely necessary instead of a source of danger.

By morning the pipe had cooled off. A little portable grinder with a flexible shaft was secured and the welded metal ground off to the level of the flange. The metal was so hard that files would not touch it. The stuffing-box was lowered into place and the flanges were bolted together.

The job was a success and bids fair to last as long as the rest of the elevator.

A LONG TIME ago a noted specialist said that his secret of success as a physician was keeping the patient's head cool and his feet warm. And it is just now becoming generally known that a "hot head" and "cold feet" are enough to bring disaster to even a well man.—O. Byron Copper.

Olive Groves for Railway Fuel

HOW the Turkish depredations on the olive tree groves in the Holy Land were carried on is told by a returned Red Cross worker who visited the denuded spots and talked with many of the impoverished owners. The industry has suffered considerable hindrance by the Turkish occupation of these localities, and dealers have been forced to give their major attention to the Spanish and Italian markets, although those, too, were cut off during the war.

"During the second year of the war," said the Red Cross worker, "the military railway authorities ran short of fuel, and recruits between 40 and 50 yr. old were allowed to contract for supplies of wood in order to enable the railways to continue hauling of troops and munitions.

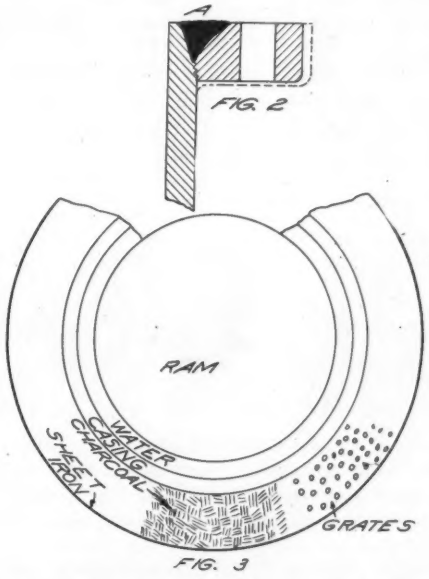


FIG. 2. DOTTED LINES SHOW ORIGINAL FLANGE CAST ON, HEAVY LINES PRESENT FLANGE SCREWED ON AND WELDED

FIG. 3. HORIZONTAL SECTION THROUGH FURNACE AND RAM

"A general order, therefore, was issued that all olive grove owners should allow 25 per cent of their trees to be cut for this purpose.

"Naturally they obeyed with reluctance. They cut and transported the wood at their own expense, receiving a fixed price, the government paying them in Turkish notes which were constantly depreciating."

At Beir Zeit, a village near Jerusalem, there are three oil mills, and all use the primitive process of a blind-folded mule hitched to a shaft which he draws round and round in a circle. The shaft operates a grinder which works in a large vat with a smaller vessel below. The oil and all the residuum of its manufacture —olive pulp and other refuse—falls into the small vessel. In time the latter is removed and hot water is poured in at one end. The pure, clean oil rises to the top and is drained off.

Olive oil was used for fuel during the war when the petroleum shortage became acute.

The Action of Lubricants in Bearings*

A Discussion of the Principles of Lubrication as Applied to Various Types of Bearings. By G. B. Upton

FROM a simple study of the action of lubricants in bearings, it will be found that, in a general way, the oil film is thinnest, between shaft and bearing, in the direction toward the load. Precisely, however, the position of thinnest oil film lies slightly beyond the line of loading in the direction of rotation. The oil film is thicker on the entering edge of a bearing surface than on the trailing edge. This difference in oil film thickness between entering and trailing edges of the bearing surfaces (identified with regard to the line of loading) would exist anyway on account of the laws of viscous flow; but it is further exaggerated in practice by the end leakage losses of oil from the bearings, which leave less oil to discharge from the trailing edge than at the leading edge.

Within the oil film there is a considerable hydrostatic pressure. This pressure is not constant throughout the area of the film. It is zero at the ends of the bearing surface, and at the leading and trailing edges, at approximately 90 deg. to the line of loading. On the side away from the load in the bearing, the hydrostatic pressure is a slight suction. It is to this region of the bearing that the oil supply should be brought, oil holes and oil grooves of a bearing should be in the half away from the load. On the side of the bearing carrying the load, the hydrostatic pressures in the oil film are positive and high in value.

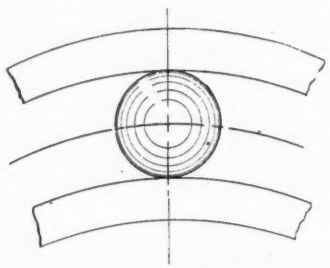


FIG. 2. BALL BEARING. SHOWING ENTIRE ABSENCE OF CLEARANCE BETWEEN BALL AND RACES, THUS HOLDING THE SHAFT IN RIGID CONCENTRICITY

Pressures in the oil film are also locally higher over high spots of metal surfaces than over low spots, as such "spots" come from roughness of surface of the bearing metal. These oil film pressures can be so high that they will actually set up a flow of the bearing metal, if that is one of low elastic limit, like a soft babbit; and flow will make the metal smooth its surface to a more perfect fit. There should be no oil grooves or oil holes in the loaded half of a bearing, as they will only provide channels of easy escape of the oil out of the high pressure region, and so thin out the oil film at just the place where we are trying to make and keep it thick.

This hydrostatic pressure in the oil film, maximum near the center of the loaded half of the bearing, is the cause of end leakage of oil from the bearing. The shorter the bearing, compared to shaft diameters, the worse does this end leakage become. End leakage makes the trailing edge of the bearing run with a too thin oil film, or in the limit, run almost dry. Generally speaking, a bearing should never be less than one shaft diameter long; and the bearing becomes perceptibly better in performance as its ratio of length to shaft diameter increases, up to three or four diameters. Beyond that there is little gain; and also such great lengths would be impossible for other reasons of design. The worst bearing ever devised by man, in this particular of relative length, is the eccentric strap bearing still common in steam engine design.

There are two considerations to be kept in mind in placing oil holes and oil grooves in bearings. The first is that they do not belong in the loaded half. The second is that the oil supply should come in at the leading edge of the bearing, to be picked up by the shaft and carried up under the load with a minimum of travel from the point of supply. This means practically that the best place for oil supply is about 90 deg. off the line of loading, and ahead of it. Trouble comes when the direction of loading is variable. In such a case, we have to search for the point of minimum loading. One fact of importance in this connection is that a load due to centrifugal force, and hence rotating at shaft velocity with regard to the bearing, is indifferent as to location of oil supply from the bearing; and all such forces may be properly neglected in locating the oil holes and grooves, if these are in the bearing. The centrifugal forces cannot be neglected if the oil supply comes through the shaft.

Grooves in the bearing should be of the simplest—a little channel from the oil hole, running out parallel to the axis of the shaft so that the length of the groove is about three-fourths of the length of the bearing. The groove should be quite a bit wider at the center of the bearing than toward the ends. The edges of the groove should be carefully and widely rounded off; they should never be sharp. A groove is made to spread oil, but it should not be forgotten that the natural end leakage of a bearing is an effective spreader of oil—perhaps even too effective, so that the groove need not do much in that line. A groove is also a reservoir of oil, to take care of starting conditions, and of intermittent character of oil supply in some systems of lubrication. Above all, grooves should never be put in the most loaded half of a bearing.

Ball Bearings

The advantages of ball or roller bearings over plain bearings are three. The starting friction of ball or roller bearings is the same as their running friction; starting friction of plain bearings is much higher than running friction, if the bearing starts under load. A plain bearing starting without load works about as easily in starting as a roller bearing. Second, the running coefficient of friction averages lower for ball and roller bearings than for plain bearings. The minimum coefficient for

* Abstract from the Sibley Journal of Engineering. The material for this article was obtained as the result of research carried on at Sibley College, Cornell University.

a plain bearing may be as low as the best of the ball bearing, but the minimum coefficient for the plain bearing comes just at the edge of seizing. Third, ball and roller bearings hold a shaft to rigid and exact concentricity. Plain bearings will do this only when operated at high speeds and light loads, and on small clearances. There is usually no necessity for concentric running of shaft and bearing; occasionally, as in a lathe headstock, it must be assured. The disadvantage of the ball and roller bearings, as compared with plain bearings, is in initial cost and cost of installation.

Ball and roller bearings do not need lubrication to reduce their coefficient of friction, except as friction comes from rubbing of balls on each other, or on the retaining cages, or of the cages on the races. Indeed, lubrication frequently raises the coefficient instead of lowering it. The main reason for "lubrication," in ball and roller bearings, is to protect from rusting. Rust protection by the "lubricant" coating the metals is quite another property from those concerned in real lubrication, though we must admit that no lubricant could be used as a lubricant anywhere if it did not have protective powers against rust.

There are three different operating cases in machinery where we try to reduce friction by lubrication. The most important is a shaft in a bearing, with the shaft in continuous rotation as the machinery runs. This is the case we have been discussing in detail. The second case is that of a wristpin in a steam or gas engine, or spring shackle bolt of an automobile. The line of loading is only slightly variable in direction; the loading may or may not reverse. The angular motion is small and is not continuous, but oscillating. In this case, the angular motion will not carry oil in to form a lubrication film, as when the angular motion is continuous, and lubrication by oil is possible only when the loading reverses regularly. At each reversal, oil runs in by combination of pressure squeezing and capillary action to the unloaded side of the pin, while being pushed out on the loaded side. The capillary action helps always to form or maintain the film. Another action of importance here is the increase of viscosity under pressure. This makes the oil squeeze out more slowly on the loaded side of the pin than it squeezes in on the unloaded side. If the pressure on a wristpin does not reverse, however, the oil will squeeze out on the loaded side and stay out. The pin may, of course, roll in its bushing for nearly 15 deg. of motion on either side of its central position before metallic slipping and wear need occur. Between this rolling action and the peculiar properties of grease lubrication, a fair lubrication of wristpins or shackle bolts may often be had when the loads do not reverse.

Kingsbury Thrust Bearing

The third important case of lubrication occurs in crosshead action, or in step or thrust bearings of the Michell or Kingsbury type. This type of bearing, shown in Fig. 2, is a form of self-adjusting bearing, generally used to take up the forward thrust of a turbine or the thrust of the propeller aboard ship. The thrust which this form of bearing is capable of taking up sometimes runs as high as 5000 lb. per sq. in. It consists of six principal parts or sets of parts, enumerated as follows: the oil clearance ring, O; the casing, J; the floating ring seats, L; the floating rings, D and K; the shaft and collar, C; and the self-alining thrust blocks, E. There are a number of segments or thrust blocks on each side of the shaft collar. These segments are made of machine steel faced with bearing metal and provided with a circular recess, G, on the opposite side. High grade tool steel, hardened pine, F, on the floating rings engage in these recesses in the segments, thus allowing them to adjust themselves so as always to bear directly against the shaft collar and to tend to avoid any unequal distribution in the amount of thrust. When in operation, the whole bearing is under an oil pressure of from 6 to 15 lb. Here, if (the *if* is very important, and must be inquired into), *if* the slipper is free to tip as its runs, so as to have the oil film thicker on the entering than on the trailing edge, lubrication may occur with automatic formation of an oil film very much as in the case of the rotating shaft. The center of pressure of the oil film under the slipper lies a bit toward the trailing edge from the middle of the slipper. Satisfactory action can be secured, however, with the hinge at the middle of the slipper—a matter of importance if the motion is reversing or reversible. The coefficient of friction in this case seems to vary directly as the fourth root of the slipper area, inversely as the square root of the load on the slipper, directly as the square roots of the viscosity

FIG. 3. KINGSBURY THRUST BEARING DISMANTLED

of the lubricant and the linear velocity of the slipper. These laws, as in the case of the rotating bearing, cannot be fully proven until by temperature and pressure measurement of the oil in the lubricating film, near where it is thinnest and hottest, we are able to know just what viscosity to impute to the oil as it works. The experiment has not been done in this case, to the extent of complete and exact agreement of theory and fact.

The laws of slipper friction quoted above will not hold if the clearance between slipper and guide, or angle of tip of slipper with regard to guide, are mechanically limited to smaller values than those to which they would go spontaneously if free. This is part of the reason why a gas-engine piston, operating as a crosshead, has excessive friction when fitted too closely to its cylinder. Gas-engine pistons and steam-engine crossheads may need a good bit of redesign if we try to improve their lubricating action in accordance with our latest knowledge. A design of slipper like the tipping blocks of Michell or Kingsbury thrust bearings need to be applied to crosshead designs.

Cutting Oils

What may be considered a fourth type of lubricating action occurs in the case of our "cutting oils" or solutions applied to cutting tools in the machine shop. Kingsbury has given the explanation of this case. The action of the "lubricant" is in part merely the carrying

away of heat, keeping the cutting point of the tool from becoming overheated and losing its temper. With this cooling goes real lubrication, preventing still higher frictions. A little crack forms in the work being cut, just ahead of the cutting "point" of the cutting tool. This crack fills with lubricant by the capillary action, or surface tension effect. Temperatures being high the surface tension of the lubricant is very low, and it will fill the little crack very rapidly indeed, unless the (bulk) viscosity of the lubricant is too high. To this rapid filling of the crack, high viscosity is a detriment. The chip being cut off bends outward and slides across the top of the cutting tool, tending to a metallic contact with high pressure at a point a little bit back from the cutting end of the tool. It is at this point of contact of chip and tool that lubrication is needed. The lubrication depends upon the "body" or "oiliness" of the lubricant; in other words, the viscosity should be high when the lubricating film becomes very thin and subjected to high pressure. The previous requirement must not be forgotten that the bulk viscosity must be low, to permit the lubricant to run into place.

Fishing for Heat Units

UNCLE HIRAM USES A NOVEL METHOD OF INSTRUCTING THE NEW FIREMAN HOW TO SAVE COAL. BY CHARLES C. PHELPS

UNCLE HIRAM is an engineer of the old school and a disciple of Isaak Walton. Fish and Efficiency are his two great hobbies. Even the simplest instructions to his assistants are always punctuated and embellished with fish stories. Of course, there is a reason for his love of the denizens of the briny deep. As a lad, he gave all his time to helping his father catch fish down on the Cape. Schools of fish were the only schools he had ever attended, but he has more than made up for his deficiency of book-learning by close observation backed by careful study of the technical papers. His advice is always good and his instructions given the other day to a green fireman are worth repeating here: "Now, mind yuh, it ain't the amount of coal combusted, but the amount of heat y' git that counts. Catchin' heat is jest like catchin' fish——"

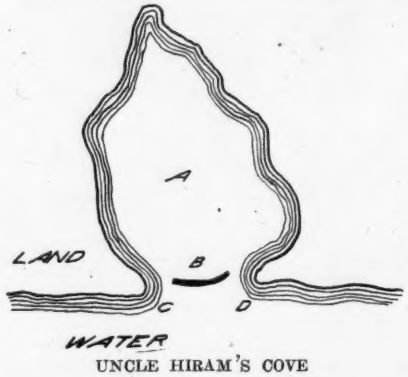
"Sure, it's the net catch that counts," interrupted the new fireman.

"Quit yer kiddin', I'm as serious as a clam," replied Uncle Hiram with a frown. "In the first place, you've got to spread your net across the great white fishway. The tubes and surfaces of the boilers are the net to catch the heat units. Just as the net must be in good condition to prevent the fish from escaping, so the boiler surfaces must be kept free from soot and scale or some of the heat units will escape. Lead the fish to your net. A little bait judiciously placed will line 'em up like sardines in a box; likewise good baffling guides the heat along the path where the boiler net can scoop it up."

"Do I have to use that Company-two machine over there?" asked the new fireman.

"I s'pose you mean the CO_2 recorder. You can read all about it in this book by Professor Flugass, but I could show you a heap better how it works by taking you some time to see how they fish up at Catfish Cove Inlet. Up at the Cove there is an inlet like A. As the tide comes in the fish go into the cove for a lark and later they follow the tide out. For close onto forty years old Jed Hawkins went and spread a net at B and the blamed net didn't no more than go halfway across the inlet. He caught about half the firsh, but the other half beat it out around the ends of the net. I asked him why he was so philanthropic like to the fish. He replied that he wuzzn't, but that if he had used a bigger net he would have to get another man to help him. So I showed the poor fish that he didn't need a bigger net, but that he could close up the opening by placing a few rocks at C and D. He did this and ever after caught all the fish instead of only half of 'em.

"Now, s'posin' you have too big a stream of hot gases flowing through for the size of your boilers, one way to catch more of the heat units would be to increase the size of the boiler heating surfaces, but that would mean more expense and a whole fleet of other difficulties. The other way is to reduce the volume of the stream of hot gases just as the size of the stream of water was reduced to the quantity that could flow through the net B. Most fireman let twice as much air as they really need into their furnaces and some of the heat units that ought to go into the boiler go to heating up this excess air instead. And remember that all this



UNCLE HIRAM'S COVE

excess air must be heated up to 500 or 600 deg. before it is discharged up the stack. That CO_2 recorder simply tells you when you are using more air than necessary; in other words, it tells you when to place rocks at C and D so's to let as few of the valuable B.t.u. fish as possible slip by the boiler net.

"More fuel is wasted due to using too much air than from any other cause. Jest remember that you are doing mighty fine if y' git 10 lb. of steam from a pound of coal and yet you must use 15 lb. of air in combusting the 1 lb. of coal in order to get the 10 lb. of steam. There again the science of fishology teaches us a lesson. Fish require air and they get the small quantity they need from the air that is dissolved in the water, but jest pull a fish out of water and give him too much air and he flaps his flippers and enters the kingdom of soused mackerels. Give a heat unit too much air and it becomes as slippery as an eel. Although you may catch its head in your boiler net, its tail will go slipping up the chimney. When you use twice as much air as you really require you will be losing about twice as much heat up the chimney as necessary. Use three times too much air and you will lose three times as much heat up the chimney as is really necessary. For

example, in this plant we ought to use about 15 lb. of air for every pound of coal and I have doped out that that means 15 per cent CO_2 in our case. I have also doped out that that means about 1/6 of the fuel is lost up the chimney. We can't avoid that loss. Now s'posin' you didn't understand that too much air is bad for a heat unit's gills and you gave each pound of coal 45 lb. of air. Your recorder would then show up 5 per cent CO_2 and about half of the fuel would go up the flue, and that is no fish story either. So you see you've got to be just as sparing with your air as with your fuel. And remember that it is right up to you as to whether your heat units are minnows or whales."

Power for Steel Works

IN a paper before the Iron and Steel Institute, C. A. Ablett stated that it is now agreed that the cheapest way to get power in iron and steel works is to utilize blast furnace and coke oven gases and other waste heat to the fullest extent. Economically used, these will usually be found to provide all the power required.

If large slow-speed alternators are driven by gas engines, resonance effects may be produced. A large flywheel alternator excited and disconnected from its engine will have a certain inertia and will be acted on by magnetic forces between field and armature. If the flywheel be pushed forward slightly in the direction of rotation, it will swing back and forth in a natural period of vibration similar to the action of a pendulum. This period of vibration can be altered by changing the inertia of the flywheel or by changing the excitation of the field.

A similar oscillation may be produced while the alternator is running by a sudden overload or other cause and it will then move first faster, then slower than its average speed of rotation. If alternator and flywheel are properly designed, this oscillation will quickly die out. But if the natural time of vibration coincides with the time between working strokes of the engine or certain multiples of this time, the oscillation may be increased so that it is impossible to run the engine.

For gas-engine-driven units run in parallel, the time of vibration of one alternator may coincide with the time between working strokes of another engine so that the units cannot be run in parallel.

To avoid such resonance, a proper weight of flywheel must be selected, usually greater than would be necessary if the engine were not driving electrical machinery, but if the flywheel be too heavy, the effect may be as bad as if it were too light.

When driving d. c. generators, these resonance effects do not occur, hence a lighter flywheel may be used. Also d. c. machines for gas engine units are usually less in first cost than a. c. machines, which is an added advantage for using d. c. motors for steel mill work.

When using turbine-driven sets, both a. c. and d. c. generators work without difficulty, the a. c. usually direct coupled but the d. c. frequently having a slow-speed generator connected by helical gears to a high-speed turbine. If the turbine is to run at over 3000 r.p.m., it will be necessary to gear the a. c. generator also or to use a frequency higher than 50 cycles which is common English practice. The d. c. geared unit is higher in first cost than the a. c., hence this difference must be balanced against the lower cost of d. c. motor equipment for driving the mills.

As to connecting up a steel-works system to a central station system, it has been argued that the central station provides a standby, and that surplus of power from the steel works plant may, in turn, be sold to the central station. Mr. Ablett argues that if equipment be maintained for a standby, the charge must be so great as to be uneconomical; and if this is not done, there is no assurance that the standby power will be available when needed. It would seem better for the steel works to install its own standby plant and thus control its own service at all times. If the service be charged up at the same rate that would be paid to the central station, the standby plant will soon be paid for and the annual charge will be eliminated.

Sale of power to the central system is usually at a low rate, and probably must be so as the surplus from the steel works will generally be available when of least value to the central system, i. e., at off peak periods. The interests of the steel works and the central station do not coincide, and it would seem more profitable for the steel works to provide for its own needs and find means for using its own surplus power.

In this opinion Mr. Ablett was backed up by F. P. Clarke and H. Crowe, who thought that better than coupling to a central system would be to couple to other works having blast furnaces and rolling mills so that each might serve as a standby to the others. Coupling to an outside system usually involves the use of 3-phase power which was shown to be less desirable than d. c. for rolling mill work. One disadvantage of the proposed super-power station scheme was the tendency to use 3-phase power for all purposes, whether it were the best adapted for a given plant or not.

A Rising Business

WHILE it may be possible that some member of the family of electrical supply artisans might believe that the bottom has fallen out, or that it is not destined for better days, it is a safe bet that the majority know that the present is as good a time as any if the proper spirit is behind it.

Out in Denver, Colo., Manager Easter, of the Easter Electric Co., finding that delivery by express or parcel post was too slow for rush orders, has contracted with the Curtiss Humphrey Airplane Co. to deliver goods by aeroplane all over the state of Colorado.

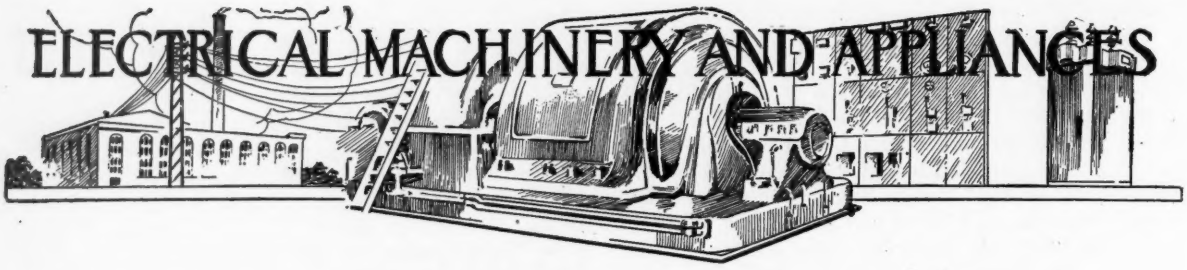
Just think of it! A customer one hundred miles away might give an order by telegraph or telephone and get his goods delivered in a couple of hours.

Of course, it is not to be inferred that trivial orders will be given this specialized service but whenever the occasion warrants, the scheme is to be utilized.

Verily, it is a progressive age.

J. B. DILLON.

A LADY on being told how easily the metric system could be learned, replied, "I do not believe I could ever learn the meter, so as to think of it other than as 1 yd. 3 in. and a little more."



A Study of Dynamo Electric Machinery---XVIII

THEORY OF THE INDUCTION MOTOR. ITS CHARACTERISTICS AND APPLICATION. BY OTTOMAR H. HENSCHEL

UNDERLYING the operation of the induction motor is the principle of the rotating magnet field, which may readily be explained with the assistance of the diagram of connections (A) and the sinusoidal curves (B) in Fig. 127, the latter representing the theoretical electromotive force waves of a typical two-phase generator. At (A) is shown a four-pole motor frame and an iron armature free to revolve upon shaft P. Connected to one phase, that is, phase A, are coils N and S in series, while coils N′ and S′ also oppositely placed and in series are connected to phase B.

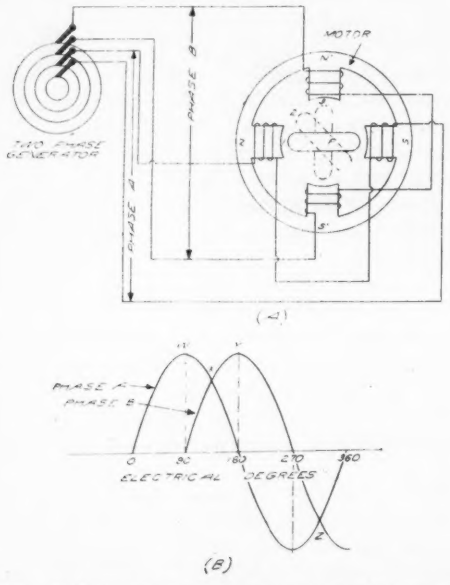


FIG. 127. (A) DIAGRAM ILLUSTRATING MEANS OF SECURING A ROTATING MAGNET FIELD. (B) SINUSOIDAL E. M. F. CURVE OF A TWO-PHASE GENERATOR

With the armature of the motor in the position indicated by the solid heavy lines and starting with the electromotive force wave of phase (A) at zero (electromotive force and current being in phase throughout this discussion), it is evident that the value of the current flow through phase A and the resulting magnetization of poles N and S increase from zero at 0 deg. to a maximum value of W at 90 deg. As a consequence (for the moment neglecting the effect of phase B), the armature of the motor will be held in position with a corresponding increase of magnetic intensity until point W is passed when the holding power of poles N and S decreases and the effect of phase B, that is, the effect of poles N′ and S′ increases in intensity, thus causing movement of the armature from dotted position 2 to dot and

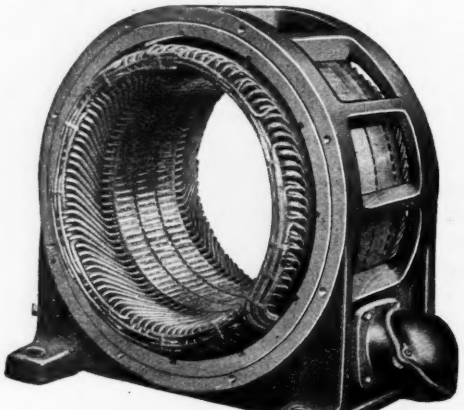


FIG. 128. TYPICAL INDUCTION MOTOR STATOR

dash position 3. Following the path of the electromotive force (or current) curves of phases A and B, it is seen that the latter decreases in value while that of phase A increases in value but in a negative direction and, as in moving from poles N and S to N′ and S′, the armature

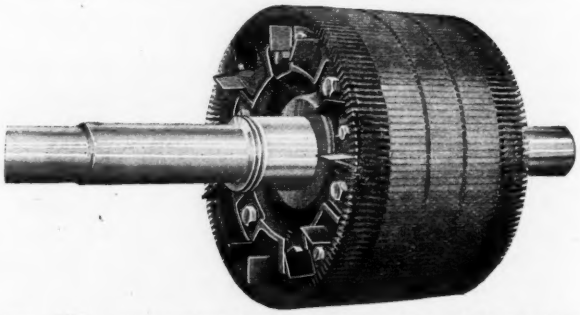


FIG. 129. INDUCTION MOTOR ROTOR WITH ELECTRICALLY BRAZED END RINGS

moves from N′ and S′ to N and S. From the 270-deg. point, the action is similar to that from the 90-deg. point and the cycle thus repeated.

In the actual motor no armature of the form shown in Fig. 127 is used but rather a drum-shaped structure

supported by a spider mounted on the shaft and made up of laminated steel secured in place by means of rigid end pieces. In one type of induction motor, the simplest and generally referred to as the squirrel-cage motor, the periphery of the drum is provided with slots parallel to the axis of the shaft and carrying copper conductors generally not insulated from the structures but joined at their terminals to a short-circuiting ring. The form of construction employed is similar to that shown in Fig. 129. When the windings of the motor are connected to

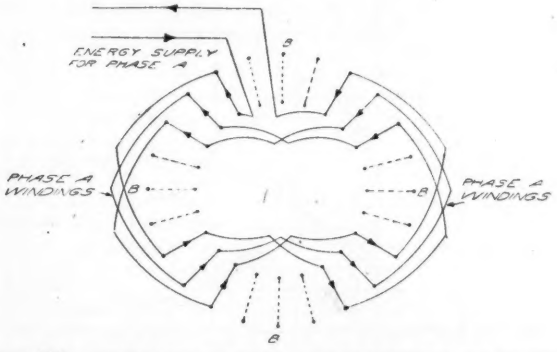


FIG. 130. SCHEMATIC DIAGRAM OF CONNECTIONS FOR STATOR WINDING FOR TWO-PHASE, FOUR-POLE INDUCTION MOTOR

some source of energy supply (which, in the case of all but the very smallest sizes of machines, is through the medium of some form of auto-transformer or compensator providing a low starting voltage) the revolving field is immediately set in motion, currents are induced within the rotor conductors and, due to the resulting reaction between the current flow through these conductors and main field, the rotor is set in motion, gaining in speed until (assuming no load is being carried) this speed is equal to that of the revolving field. At this point, that is, if no relative motion between the revolving field and

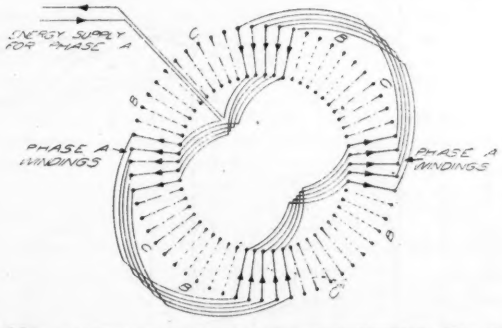


FIG. 131. SCHEMATIC DIAGRAM OF CONNECTIONS FOR TYPICAL FOUR-POLE, THREE-PHASE INDUCTION MOTOR

the rotor exists, no electromotive forces are induced in the rotor conductors, no currents flow and as a consequence the torque is of zero value.

With a load thrown upon the motor, however, the speed of the rotor is lightly decreased, the difference in speed between the rotor and that of the magnetic field increases, an electromotive force is induced in the rotor windings, a flow of current established and the torque increased to such a value as to enable the motor to carry its load. The increase in torque due to this action is, however, not exactly proportioned to the difference between the rotor and magnetic field speeds, this because of the fact that as the current flow through the rotor conductors increases the demagnetizing action of the rotor currents increases, thus resulting in an increase of torque at a rate much slower than the increase in speed difference.

The difference between the speed of the revolving field and that of the rotor is referred to as the slip and generally is expressed in per cent. Subtracting the speed of the rotor from that of the rotating field and dividing this difference by the speed of the rotating field will give as a quotient the slip, as a decimal. Multiplying by 100 will give the per cent slip.

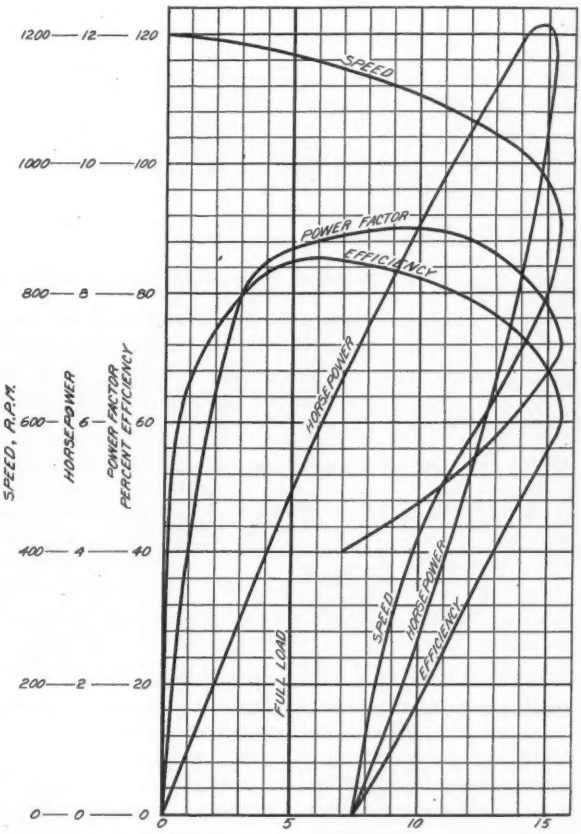


FIG. 132. CHARACTERISTIC CURVES OF A 5-HP., THREE-PHASE, SIX-POLE INDUCTION MOTOR

As a rule, the per cent slip of an induction motor varies inversely as the horsepower rating. For a 3-hp. machine, a slip of perhaps 9 per cent may be expected; for a 5-hp. motor about 7 per cent; for one of 10 hp., 6 per cent; for one of 25 hp., 5 per cent; and for a 35-hp. motor approximately 4½ per cent.

Machine Windings

Stator or primary windings of the actual induction motor are not arranged as those shown in Fig. 127. A scheme such as indicated in Fig. 128 is employed. Within a cast-iron or rolled steel supporting and enclosing member is placed a laminated iron core provided with slots in which are placed the coils in a manner similar to that employed in the ordinary direct-current armature. Unlike the direct-current armature, however,

the teeth of the laminated member project inwardly rather than outwardly. This construction is well illustrated in Fig. 128.

The stator windings are arranged exactly like the armature windings of a polyphase alternator. Figure 130 illustrates diagrammatically the arrangement employed in conjunction with a typical four-pole, two-phase machine, connections for but one phase winding being shown in order to avoid complexity. Slot conductors are represented by the short radial lines, while the end connections are represented by the internal and external curved lines. Windings for phase B would be exactly like those shown for phase A.

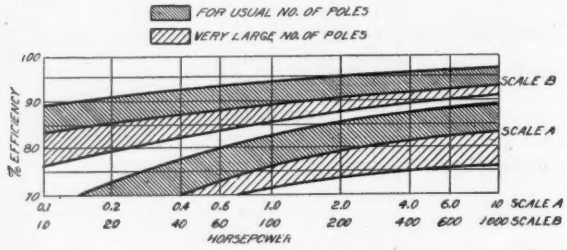


FIG. 133. EFFICIENCIES OF AVERAGE INDUCTION MOTOR

In three-phase machines, three sets of coils are used in the manner indicated in Fig. 131 which illustrates a diagram for a four-pole, three-phase winding. As in the case of the two-phase winding diagram, but one phase winding is shown.

CHARACTERISTICS

ESSENTIALLY the induction motor is, throughout its range of capacity, a constant speed machine. If, however, such a motor is loaded beyond its rated capacity its speed will decrease up to a definite point, after which further decrease of speed, with corresponding decrease in horsepower output, will result until the machine is brought to standstill. This characteristic is well illus-

FIG. 134. STARTING CURRENTS REQUIRED BY THREE-PHASE, SQUIRREL-CAGE INDUCTION MOTOR

Motor voltage in per cent line voltage	Line starting current in per cent of full load current	Motor starting current in per cent of full load current	Starting torque of motor in per cent of its full load running torque
40	112	280	32
60	250	420	72
80	450	560	128
100	700	700	200

trated in Fig. 132, showing characteristic curves of a 5-hp., three-phase, six-pole, 220-v. induction motor.

Maximum efficiency is not reached until the motor carries full load, after which it gradually decreases to maximum output, followed by an abrupt decrease until at standstill it becomes zero.

The power factor curve up to a maximum output follows closely the efficiency curve although beyond this point its decline is not nearly as marked as that of either the power factor or the speed.

Horsepower and line current curves are of the forms indicated.

Curves indicating friction losses, core losses, primary copper losses and secondary copper losses are representative of those applying to a 5-hp. machine, although, due to the fact that the smaller the number of poles and the higher the frequency, the higher is the efficiency, these curves vary somewhat with different designs.

Efficiencies of average induction motors are as shown in Fig. 133, taken from the Standard Handbook for

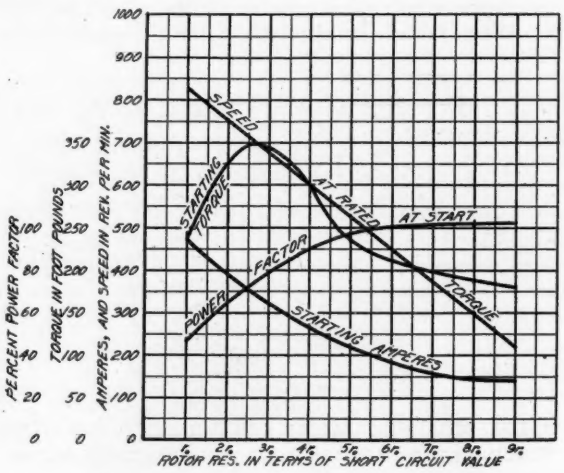


FIG. 135. EFFECT OF CHANGE OF RESISTANCE OF ROTOR CIRCUIT UPON PERFORMANCE OF A 20-HP. INDUCTION MOTOR

Electrical Engineers, as is also the table, Fig. 134, giving the currents taken by three-phase, squirrel-cage induction motors at the moment of starting.

By the introduction of a variable resistance in the rotor winding circuit of a wound-rotor type of induction motor, the speed of such a machine may be varied

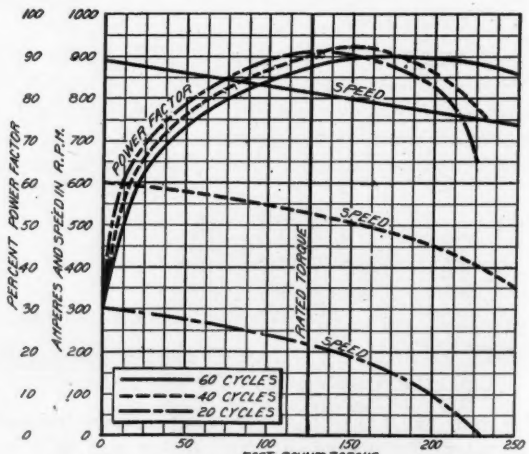


FIG. 136. EFFECT OF CHANGE OF FREQUENCY UPON PERFORMANCE OF A 20-HP. INDUCTION MOTOR

within a wide range. The effect of such a scheme upon the performance of a 20-hp. motor is illustrated by the curves shown in Fig. 135.

Where change of speed is accomplished by means of altering frequency of the supply voltage, corresponding

power factor, speed and current variation will be as indicated in Fig. 136.

Application of Induction Motors

Low-slip motors, that is, machines having a slip of from 2 to 5 per cent, are generally considered as constant speed motors and are particularly applicable for such service as the driving of generators, centrifugal pumps, textile machinery, etc. Motors of this type when equipped with squirrel-cage rotors should, however, not be connected to a line when the capacity of the machine is in excess of 35 per cent of the capacity of the generator furnishing the energy, especially if starting conditions are unusually severe. In work requiring a starting torque high as compared to the running torque, a squirrel-cage motor having a slip of from 8 to 12 per cent may well be used; while, for such service as the operation of elevators and hoists where the greater part of the work consists of starting and accelerating the load, squirrel-cage motors having slips of about 20 per cent are employed.

Variation of the external resistance on a wound-rotor motor provides a condition parallel to that existing in any of the various classes of squirrel-cage machines, so that the speed-torque characteristics of a wound-rotor motor are governed entirely by the operation of the control used in connection with it.

Questions and Problems for Review

Explain the theory of the rotating magnet field.

2. What is meant by the "slip" of an induction motor? What per cent slip would you expect to find in a 10-hp. motor?

3. For what class of service are motors with a low slip particularly well suited?

Generator Failures*

Classification of Breakdowns of Large Turbine-Driven Machines. By Philip Torchio

EXPERIENCE with this class of electrical apparatus is in a measure less satisfactory than could be desired. The design difficulties are undoubtedly greater than encountered in the design of low-speed generators as used in hydroelectric plants, but the exacting service requirements of large steam power undertakings demand the maximum of reliability from its generators. To meet these requirements, designing engineers must ultimately produce apparatus more dependable. At the same time, users must install and operate their generators under conditions that will be most favorable to their maintenance.

The size of generators investigated ranged from 5000 to 30,000 kw., the larger units being of more recent manufacture, while the smaller date back from 12 to 16 yr.

The total failures, several occurring on the same unit, amounted to 55, of which 33 occurred in armatures, 16 in fields, four in armatures and fields, and two in terminals.

The classification of all these generator troubles is as follows:

Armature failures due to:	
Mechanical damages	3
Heating of windings	17
Heating of iron	2
Loose laminations	1
Moisture in cooling air	3
Corona shield breaking	2
Heating at end turn clamping	1
Overload damaging end turns	2
Causes undiscovered	2
	33
Field failures due to:	
Open-circuited connections	3
Grounding	7
Grounding caused by bus short circuit	4
Loosening of damper windings	2
	16
Armature and field failures due to:	
Moisture	1
Undiscovered	3
	4
Terminal failures due to:	
Moisture	2
	2

From the above analysis, it appears that at least 50 per cent of armature failures are due to heating, damaging the insulation. To avoid similar troubles, designing engineers should use insulating materials of proved dependability, maintain low copper temperatures by proper subdivision of copper and transposition of strands in windings and provide liberal ventilation throughout the machine. The operating copper temperatures should be limited at or closely to 100 deg. C. Too great range of operating temperatures is bound to cause generator failures.

It may be appropriate here to emphasize a broad general principle to which perhaps we have not given full consideration in the past, and that is that insulated electrical apparatus subjected to too wide operating temperature ranges may be seriously impaired by mechanical bulging and damages to the insulation and the incasing structure, without inherent deterioration of the insulation itself. We found that the insulation, while excellent to withstand the maximum temperatures, was mechanically damaged by the expansion and contraction of the copper which it surrounded. For instance, mica insulation installed in hydroelectric generator armatures, which have only a small fraction of length of a turbo generator armature and are operated at a practically steady continuous load, last indefinitely at high temperatures, while mica insulation, under same or lower temperature conditions, in steam turbo generators operated at partial loads for several hours, then loaded to a maximum and later shut down every 24 hr., will fail.

To weed out cracks or latent defects due to defective workmanship at factory or in installation, the test voltage for windings should be raised to three times full voltage plus 1000.

The large number of field failures on generators of

* Abstract of paper presented at 36th Annual Convention of the A. I. E. E.

older design using fibrous insulation were practically eliminated in more recent designs by the use of mica and asbestos tape insulation.

Experience seems to indicate that a solid forged field has greater resistance to field stresses under bus short circuits than laminated field structures or even structures made up of end plates and several central plates a few inches in thickness.

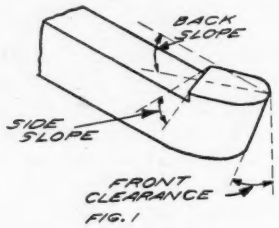
The loosening of damper windings seems to have been satisfactorily overcome, from the experience of the last few years.

From the standpoint of the users, it appears important that great care be exercised in the supply of cooling air to prevent moisture or condensation depositing on the windings.

Lathe Work

Notes on Tools, and Methods of Setting Up Work for Turning, Facing and Boring

GIVEN a suitable lathe, the operation of the machine depends upon the use of properly shaped tools, correct cutting speeds and efficient methods of setting up. The shapes of the tools and the cutting speeds for different material have been, to a great extent, standardized. Standard lathe chucks are used for holding the work wherever possible, but for setting up repetition work special chucks are usually employed. This is particularly true of the larger shops. In small shops, on the other hand, the tool shape and cutting speeds are largely based on the experience or judgment of the individual.



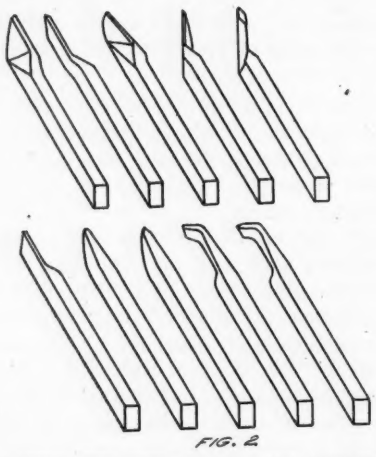


FIG. 1. LATHE TOOL WITH NAMES OF ANGLES
FIG. 2. TYPICAL TOOL PROFILES

Figure 1 shows a lathe tool with the names of the various angles or "rakes." A tool for turning a medium grade of steel, such as cold rolled, should have a front rake of about 8 deg., the extreme limits being 6 and 10 deg. This angle is provided to allow the tool to be fed into the work, and to reduce friction. Theoretically, the angle necessary for cutting is smaller, but as the metal being turned is more or less elastic, and springs outward into contact with the front of the tool after the cutting edge has passed, and the area of contact is therefore greater than the edge of the tool, a greater angle is used to reduce friction.

The actual top rake depends on a combination of back slope and side slope. Back slope should be about 8 deg. and side slope from 15 to 20 deg. The actual included angle of the tool point for medium grades of steel should be about 61 deg.

For harder steel and for cast iron, the tip angle is made about 68 deg. to provide added strength to the cutting edge. The front angle and the back slope should not be changed; the alteration should be made in the angle of the side slope. For chilled cast iron, which is rarely used in the ordinary run of work, an angle of about 86 deg. is used, to give sufficient strength to the tip of the tool.

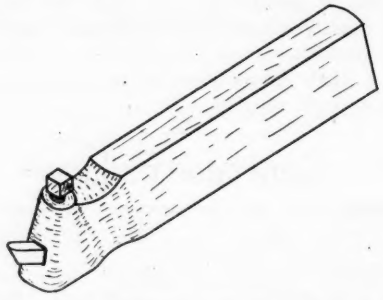


FIG. 3. A DROP-FORGED LATHE TOOL-HOLDER

Brass requires a somewhat different tool. The front rake is usually about the same as for steel, but sometimes increased to 12 or 14 deg. The top, however, has no rake; it is absolutely flat. It may even be of advantage on some jobs to use a "negative" rake, that is with the top surface sloping downward towards the work.

The profile of the cutting edge depends on the work to be done. Ordinarily a rather broad round nose tool is used for roughing cuts, but it is often necessary to use a narrow tool to prevent chattering. For the finishing cut on steel, a narrow round-pointed tool is generally used, with a slow feed. On cast iron, broader cuts are taken with a wider tool and faster feed, while a round nose tool with a slow feed is used to finish brass. A few typical tool profiles are given in Fig. 2.

Cutting Speed

BEYOND A CERTAIN cutting speed, the life of a lathe tool rapidly decreases. The rate of cutting should therefore be kept within certain limits. Using high-speed steel tools, the cutting speed for iron is from 40 to 50,

for steel 60 to 75, for annealed tool steel 25 to 35, and for brass 75 to 100 ft. per minute. The lower speeds are for roughing cuts and the higher for finishing.

One of the difficulties frequently encountered in lathe work is chattering. This is caused by several conditions, the most common of which is vibration of the work due to its own weakness, or to too great overhang of work mounted in the chuck or on the faceplate. Other contributing causes are loose headstock bearings, incorrectly shaped tools, badly fitted gears and too high speeds It is often possible for one man to take a tool that had proved a chronic chatterer in other hands, and, with no alterations other than in its setting, produce good work.

In the matter of saving of tool steel and elimination of forging the various tool holders on the market, similar to that shown in Fig. 3, are worthy of consideration. Most of these are made to hold small tool bits in such a position as to give about 15 deg. back slope without

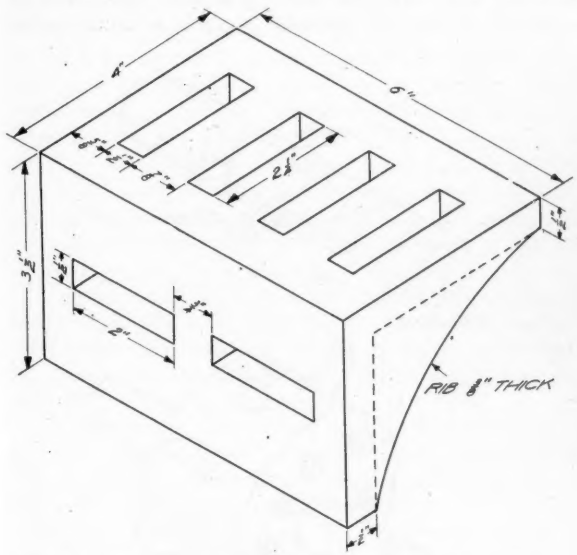


FIG. 4. ISOMETRIC VIEW OF SMALL CAST-IRON ANGLE PLATE

grinding on top. Thus a tool suitable for iron and steel can be formed simply by grinding to the proper profile, and with the correct front rake. The side slope may be altered to some extent simply by swinging the whole toolholder to one side.

Mounting Between Centers

In mounting work between centers for turning, probably the most important point is to see that the centers are true with each other. That does not mean that they must be exactly centered, but that their axes must coincide. If they do not, they will not accurately fit the lathe centers, and wear during the turning operation may impair the accuracy of the work.

The best way to drill the centers truly, in a small shop is, first, to center the rod, both ends, as truly as possible with a center punch. (Punches with a bill attachment facilitate this operation.) Then with a combination center drill held in a chuck in the live spindle, one of the centers is drilled, feeding the work to the drill by means of a tailstock screw, the back center bearing in the center punch mark in the other end. The rod is then reversed and the other end drilled in the same way.

Any of the various forms of dogs may be used to drive the work. It is a good plan to use only the regular catch-plate for driving the dog, for if an accurately finished faceplate is used, the pressure and impact of the arm will be likely to raise a ridge on the faceplate which will destroy its accuracy for some work.

Chuck and Faceplate Work

The two most common types of chucks, the independent and self-centering are supplied in both three- and four-jaw types. The most useful of the two types, when only one can be had, is the independent chuck. The self-centering chuck is suitable only for round and certain other classes of work, and unless treated with consideration, it soon belies its name Its accuracy in the first place is dependent on the care with which its back plate is fitted.

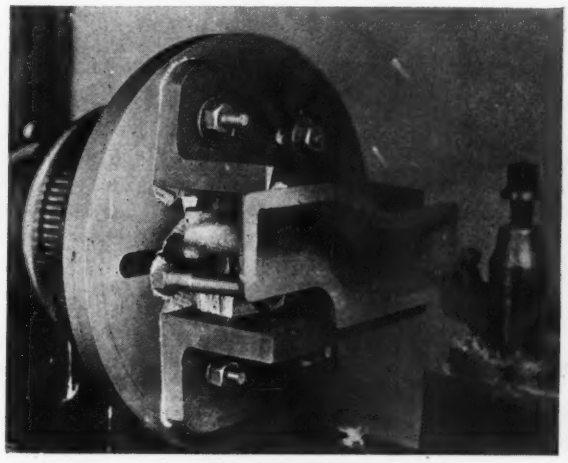


FIG. 5. UNUSUAL METHOD OF USING ANGLE PLATES

Faceplate work frequently requires considerable ingenuity in setting up. The first requisite is a flat surface on the casting or other work to bear on the faceplate. Work is usually fastened in place by means of clamp dogs, held by bolts passing through the faceplates or by the use of flat steel bars of suitable size, bored for the clamping bolts. Special forms of chuck jaws also are available, arranged to be bolted to the faceplate. The requirement in mounting work on the faceplate is sufficient solidity to withstand the strain of cutting, without springing or slipping of the work. Due to its own inherent weakness, or to the great distance which it overhangs from the lathe bearing, it is frequently necessary to provide additional support for some work. This may be done by use of the steady rest to support the end if truly round, or by accurately centering the overhanging end after the work is mounted, and using the tail-stock center to provide stability. Slipping between the work and faceplate can be prevented by inserting a thin sheet of paper between the two, when bolting up.

Frequently a surface is to be faced at right angles to another, or a hole bored parallel to a surface. For jobs such as this, an angle-plate will prove useful. For

light work, one could be made from a piece of steel angle properly trued up; but the better plan is to employ cast-iron angle-plates, of the type shown in Fig. 4, which are much stiffer.

An unusual application of angle-plates is shown in Fig. 5. Two of the same size were used in setting up a casting that was to be faced off on the bottom surface. There were four bosses on the upper surface; three of these rested on the edges of the angle plates, the fourth

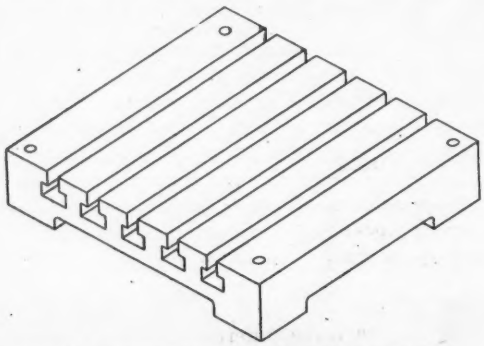


FIG. 6. ISOMETRIC VIEW OF BORING TABLE

being supported by a bolt, provided with a nut for adjustment of its length. The casting was held in place by a bar passing through the tunnel, through which the boring bar extends, in Fig. 7. The clamping in a case of this kind must be done in such a manner as not to distort the casting, and still be sufficiently firm to withstand the cutting strain.

The Boring Carriage

THE LATHE CARRIAGE, with a few extra fittings, offers opportunity for a wide range of work. Most modern

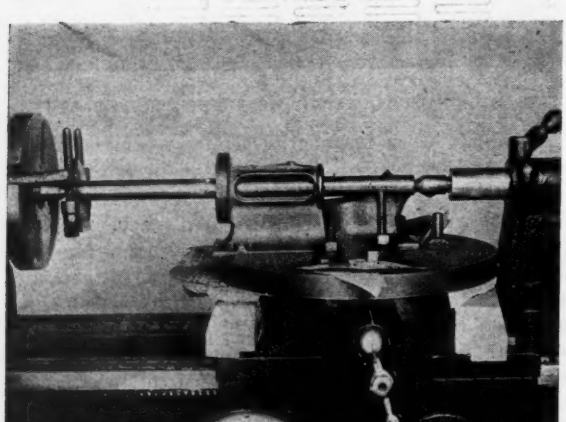


FIG. 7. ILLUSTRATING THE USE OF A FACE-PLATE AS A BORING TABLE

lathe carriages are provided with T-slots for bolting down work to be bored, but while this is useful, particularly for large work, it is often more convenient to have an extra boring table, which can be bolted to the carriage, bringing the T-slotted surface closer to the lathe centers, and providing a wider range of holding-down points. An example of such a boring table is given in Fig. 6.

It may be possible to fit the boring table to the vees of the cross slide, so as to secure cross traverse. On most lathes, however, the cross slide vees are so close together that this would cause too great a strain to be placed on them. It is better to provide four feet to bolt to the carriage.

The faceplate may often be used as a boring table by so mounting it on the carriage that its surface is truly horizontal and parallel with the lathe center line. This may be done by packing it up to the proper height with wood blocks and bolting firmly in place by means of bolts, passing through a strap under the bridge of the carriage. The bolts must not be drawn up so tight as to strain the carriage. Figure 7 shows a faceplate used in this manner, to bore a tunnel in the casting shown set up for facing in Fig. 5.

Several forms of boring bars are used on work mounted on the lathe carriage. The simplest is a piece of round or square steel centered at both ends, carrying a ground cutting tool fastened in place, in a hole in the

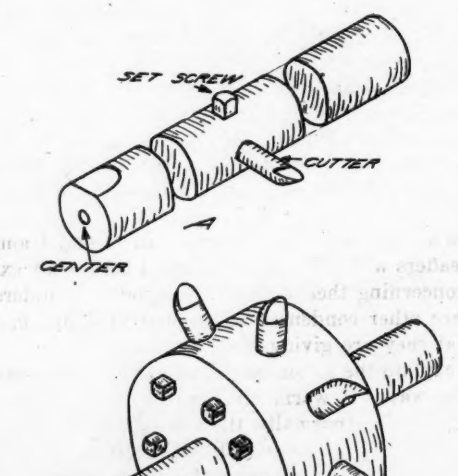


FIG. 8. TYPES OF BORING BARS

bar, by means of a set screw. This type, which is illustrated in Fig. 8A, is driven by means of an ordinary lathe dog. Another form is shown in Fig. 8B, that carries a cast-iron boring head, in which are mounted a number of cutters. With this type of bar, work can be done much faster than with the single cutter bar, as the feed can be increased in proportion to the number of cutters, depending, of course, on the ability of the lathe and the work to stand the added strain imposed upon them. In the case of this multiple cutter bar, however, great exactitude is required in setting the cutters, because there is no practical method of making them with a recess to insure their even projection from the bar, since the cutters are narrow, and generally cut across the whole diametrical face, so each grinding affects their distance from the bar, and hence the size they bore.

Ammonia Condensers

SOME HINTS REGARDING THEIR CARE AND OPERATION. BY W. A. DARTER

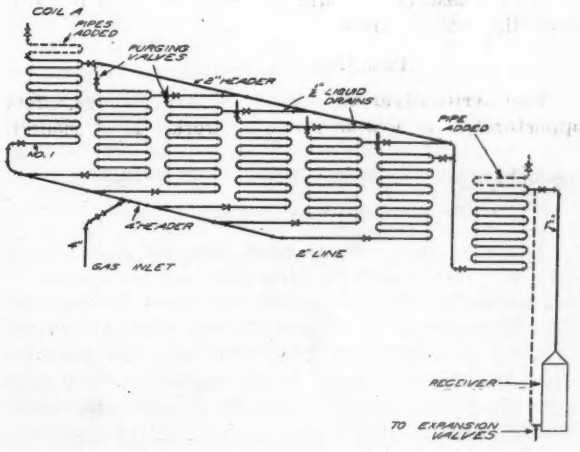
IN THE homemade condenser shown herewith are seven sections of coils with 12 pipes to the section; one section of the seven is used to cool the liquid ammonia before it enters the receiver.

In this condenser, the discharge pressure would never fall below 175 lb. gage no matter what the outside temperature was. As the cooling water temperature decreased, the lower part of a section would become cold, one pipe at a time, until the greater part of the section was cold. The colder the cooling water was, the greater the number of sections which would become cold until only one or two sections were left warm from bottom to top.

This statement, I know, seems radical and I am sure some readers will differ with me, but I believe my explanation concerning their action is adequate. I understand there are other condensers connected in a like manner, and that they are giving good service.

To explain the action of the condensers, let us assume that the water is warm and the discharge pressure is around 200 lb. (normally the head pressure should be about 185 lb.). Examine all the sections of the condenser and you will find all the pipes warm, showing that all pipes are in service and the hot ammonia gas is entering each section. Now cool the water and the pressure will drop to about 175 lb., and all the sections will still be warm from bottom to top. Cool the cooling water a little more and for a few minutes the discharge pressure will drop but it will gradually climb back to about 175 lb. pressure. Now examine each section and you will find the lower pipes of one or more of the outside sections cold—about the same temperature as the cooling water. Cool the water a little more and another section will begin to get cold from the bottom pipe toward the top pipe, and so on until only two sections are left in service and the other four sections are cold almost to the last pipe. The discharge still shows about 175 lb.

This condition shows that there is no circulation of hot gas through the cold pipes of the condensers; and that there is always left just enough active condenser surface to require about 175 lb. pressure. Now I am told, if I cut out those sections that begin to grow cold that my head pressure will be lower; but when I cut out what seems to be dead sections, the head pressure increases 5 to 10 lb. The cause is this: As long as any of the upper pipes are warm these pipe surfaces are still in active service and the ammonia gas is entering these sections through the liquid header. It is evident that the gas is not entering from the bottom, because if it were, the lower pipes would be warm. It is also evident, if the gas is entering from above, the liquid must be leaving the lower part of the sections and running into the gas header. As proof that the liquid is leaving section A, pipe 1, I take the difference in temperature of the upper and lower halves of pipe 1, and find over 12 deg. difference between the two halves. This shows that the cool liquid is running out and that the upper part of pipe 1 is full of hot gas. This liquid, of course, is picked up by the gas entering the active sections and carried to the liquid header.



ARRANGEMENT OF HOMEMADE AMMONIA CONDENSER

The puzzling question is, why does the liquid accumulate in these inactive sections? There is no reason why the pressure at the entrance of each section should be different and enough difference to back up this liquid 4 to 5 ft. There can be but one other way, and that is suction from above; and this is the solution. When the water is cool, the gas condenses faster than it can enter through the ½-in. liquid outlets. Hence a partial vacuum is formed above the liquid and the liquid is gradually drawn to the top of the section, and the height of the liquid depends upon the amount of suction, the suction or vacuum depending upon the rate of condensing, which in turn depends upon the cooling. When the cooling water is turned off a certain dead section, the liquid will all run out and the coil will become active again.

The Remedy

Two remedies were proposed by engineers. One was to change the liquid header to the bottom and gas header to the top. This method is bad, because the cooling water then comes first in contact with the hottest gas and the hottest water comes in contact with the coolest liquid ammonia.

The other method was to install bleeders on the coils to carry away the liquid as fast as the gas condensed. This was almost impossible on account of the old age and decayed condition of the condensers.

Reasoning that if the rate of condensation could be speeded up faster than the gas could enter the liquid drain, then the gas could be made to pass up through the liquid in the pipes and thereby keep the sections in active service, two more 2-in. pipes were added to the top of each section. With these two extra pipes in service, the head pressure dropped over 15 lb. These two pipes condense the gas faster than the ½-in. liquid drain can supply the gas, hence the gas has to come up through the 12 lower pipes.

Another inconvenience given by the original installation was that the liquid cooling section emptied periodically into the receiver, and that the noncondensing gas that was trapped in the receiver had no way to escape except through the evaporating coils in the freezing tank. The liquid cooling section would fill up with liquid and then syphon over into the receiver. If the receiver became full of air or noncondensing gases, this air would hold back the liquid in the cooling coil until some of it was relieved through the expansion valves.

This trouble was remedied by installing a second pipe from the bottom of the receiver to a point inside the original drain as shown by the dotted line in the sketch. This new pipe line acts as a drain and the original pipe line acts as an equalizer.

Purging Noncondensible Gases

The two pipes are separated from the main coil by a valve, which makes purging safe and less chance to lose ammonia. When the two top pipes become cold down through the third pipe, the two pipes are cut off from the section by the 2-in. valve, and the gases are allowed to escape through the purging valve. The extra valve often saves pumping down the condensers to repair purging valves. It is a good plan to let the gas escape through water in order to detect the gas the moment it presents itself. It is important to keep the condenser well purged, because this noncondensible gas will more or less mix with the ammonia gas and form an insulating film on the pipe surfaces and retard condensation. The best method before purging is to shut down the condenser or individual sections and let the cooling water run for several minutes. The gas becomes settled and the two gases have a better chance to separate.

Care of Ammonia Condensers

The condenser takes the compressed hot ammonia gas from the compressor and condenses it to liquid ammonia. Every pound of ammonia gas delivered from the compressor must be cared for by the condenser. Every B.t.u. of heat absorbed in the ice making system must eventually be carried away by the cooling water and air that passes over or through the condenser; hence it can be seen that the capacity of the compressor and freezing tank depends a great deal upon the capacity of the condenser.

Method of Condensing Ammonia Gas

One method is by the flooded system. The gas enters the lower pipes and flows toward the top of the section. As fast as the gas is liquefied, it is taken out by the bleeder-pipes which are distributed along the end of the section. Another method is to let the gas enter the top of the condenser and flow down, and as fast as the gas liquefies, the liquid runs out the bottom pipe of the section. These two methods are called the atmospheric type. The double pipe type is similar to the second method mentioned where the gas enters the top pipe of the section and flows downward.

The condenser receives the gas as it comes from the compressor more or less superheated; and this superheat must first be absorbed by the condenser before the ammonia gas becomes saturated. More heat is then extracted from the saturated gas and it becomes a liquid. More heat, then, can be taken from the liquid.

Cooling Liquid Ammonia

Some engineers seem to think that it is either not worth while or impossible to lower the temperature of the liquid ammonia before it is used again. It is well worth while to lower the temperature as far as the cooling water will take it; and it is possible to lower the temperature of liquid ammonia to any reasonable degree no matter under what pressure it happens to be. To bring the temperature of the liquid ammonia near the temperature of the cooling water, the counterflow of water to the flow of gas is necessary.

Counterflow of Cooling Water

In the old type of atmospheric condenser, the gas enters the top of the condenser and the cooling water starts at this point also. You can readily see that the coolest water comes in contact with the hottest gas and that the hottest water comes in contact with the coolest liquid; hence the liquid cannot be any cooler than the hottest water. In the flooded or double-pipe system where the counterflow of water is used, the coolest water comes in contact with the coolest gas or liquid, and the hottest water comes in contact with the hottest gas; hence the liquid can be cooled down to near the temperature of the coolest water. This is the most efficient method, because, first, the greatest number of B.t.u. of heat can be extracted from the liquid, and second, the hot water will give up its heat more readily because of the greater difference in temperature between it and the atmosphere. This counterflow method also requires only about 60 per cent of the condenser capacity that the other method requires.

Each section of the condenser should do its part of the work. The cooling water should be equally distributed over or through all the sections. In the double-pipe type the cooling water outlet of each section should be separate in order that the temperature of the cooling water can be ascertained, and kept the same.

Housing the Condenser

Condensers are sometimes placed in the most con-

venient location without considering ventilation. Especially does it pay to place the atmospheric condenser where it can be reached by the flowing air. The air current will evaporate some of the cooling water as it flows over the pipes and will refrigerate the coils a great deal more than the average engineer would think. Some condensers, 12 to 16 pipes high, well exposed to the air currents show only about 2 to 3 deg. difference in temperature between the cooling water entering and the cooling water leaving the condensers. If the condenser is placed on the roof, it should be protected from the sun, yet not in such a way that the warm, damp air from the hot coils will be confined about the condenser.

Don't let the capacity of the plant suffer for the want of clean condensers and ventilation.

Troubles with an Absorption System

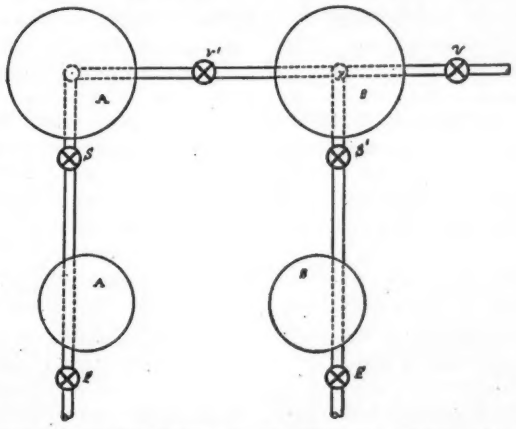
By W. S. Doan

WHILE the ammonia compression and absorption systems are well adapted for certain applications, in general, repairs are more easily accomplished in the case of the compression system. When repairs are to be made on any part of a compression system, it is simply a matter of transferring the anhydrous ammonia to some other part, usually the liquid receiver, since anhydrous ammonia only is handled; but in the case of an absorption system, aqua ammonia and anhydrous ammonia may have to be transferred, or it may be that both of these charges must be removed, for the time being.

However, ordinarily, if all of the shut-off valves are tight and in good working order, there is no great difficulty experienced in making repairs on the different parts of an absorption system, providing, of course, that the man operating the plant thoroughly understands the system, and the nature of the work in hand.

In a certain absorption plant with which I am familiar, repairs were being made in order to have the whole system in good working order for the warm summer months. As the work progressed it was found that several gate valves were practically useless. These valves had been in use so long that the gates were off the stems, so to speak. When any of these valves were closed it required considerable "coaxing" by tapping on the bottom and sides of the valve bodies with a hammer to work the gate out onto the stem to a point where the thread on the stem would enter the thread in the gate, but one day it happened that no amount of "coaxing" would move the gate of the shut-off valve in the discharge line of one of the aqua pumps, and the trouble had to be remedied before the pump could be started, since the valve was closed and wedged tightly into place. When other valves between the pump and generator were tried it was found that some of these were also "eight-day valves," which is an expression sometimes used when valves are found in this condition, and means that the hand wheel may be turned many times in either direction without moving the gate one way or the other. In order to overcome the difficulty, the aqua ammonia was withdrawn from the generator, and since this work had to be accomplished as quickly as possible, the aqua did not have time to cool, which made the work of removing it rather disagreeable, and under these conditions considerable anhydrous ammonia was lost.

There happened to be several new gate valves of the same pattern and sizes, in stock, which had been purchased from the manufacturer at a price much lower than would be the case when buying valves of the latest pattern, because the manufacturer has discontinued making valves of this particular pattern. Instead of removing the defective valves and replacing them with new ones, the old bonnets, gates and stems were removed, and these new parts attached to the old bodies. These changes were made on the recommendation of persons not employed in the plant, they probably having in mind, as in the case of the globe valves, the inter-changing of the different parts, but although it may appear to be feasible to more or less inexperienced men, the idea in the case of gate valves is wrong, since in this particular case all of the valves leaked badly after these changes were made. While hand wheels, valve stems, bonnets, etc., may be attached to a valve body already in place it is not often that the gates will fit tightly when closed,



SHOWING ARRANGEMENT OF CONDENSERS, BRINE COOLERS AND CONNECTING PIPES CARRYING THE DEFECTIVE VALVE

and since these are not so conveniently repaired in the plant, it is better to replace the valve with a new one, or, what is better if the service will permit it, replace it with a globe valve, and not "take a chance" as in the foregoing. The turnings of globe valves are standardized so that the bonnet of one valve may be placed on another, or it may be placed on an angle valve or cross valve body, and, of course, the reverse changes may be made. The turnings of any size globe valve for ammonia are the same whether the end connections are screwed or flanged. Therefore, provided the seat is in good condition, and the metal disc ring is renewed, the result is practically a new valve, and one of the main points of superiority of these valves is that they may be repacked under pressure when wide open, because a shoulder on the valve stem or lock of the disc closes against the seat on the bottom of the bonnet, forming a tight joint.

In the same plant, considerable trouble was experienced owing to a leaky gate valve located between two liquid feed lines, supplying two brine coolers.

The outlines of the arrangement of condensers, brine coolers, and connecting pipes are shown in the accompanying figure. Valve V is the charging valve. Valve V^1 is kept closed when both machines are in operation,

and is opened only when charging through cooler A, but it may be left open in case it is desired to take the supply of liquid for cooler B from condenser A, in case of repairs on condenser B and vice versa. The cause of this valve's leaking was the same as with the others: the bottom threads on the stem were found to be so badly worn that the gate could not be raised, nor could it be closed tight. The result was that more liquid ammonia accumulated in one condenser than in the other, due to some little difference in pressure, and at times, owing to a leaky feed valve on cooler B, an excess of liquid found its way into that cooler, and some of it was carried over into the absorber where it is not wanted.

In order to keep both machines in operation until new valves could be obtained, the gas pressure in the condensers was equalized by opening the valves in some small "pump out" connections, at the top, and since the pressure was the same in the condensers, the liquid levels equalized through the leaky valve V^1. Valves S and S^1 are the shut-off valves of the condensers.

Power Plant Troubles

CURING FILTER TROUBLES. REGRINDING CHECK VALVE DISCS. IMPROVING A NOISY VALVE GEAR. BY H. A. JAHNKE

WHEN RENEWING the gravel in a water filter, and before replacing the manhole plate, a new gasket of the tubular type was put on. After the plate was replaced and drawn up by a number of bolts, as shown in Fig. 1A, and pressure was turned into the

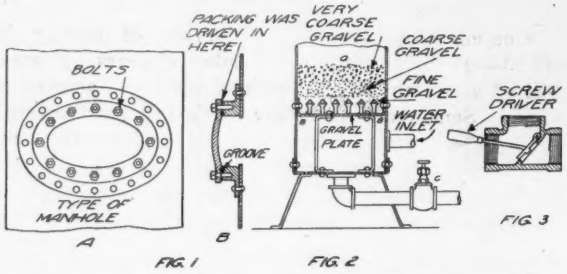


FIG. 1. SHOWING MANHOLE WHICH CAUSED THE TROUBLE
FIG. 2. SECTION THROUGH WATER FILTER
FIG. 3. METHOD OF GRINDING IN CHECK VALVE DISC

filter, the plate leaked badly. Tightening up the bolts did no good. There was no time to leave the water out of the filter again to find what caused the leak, as the water was needed badly in the plant, so, to stop the leak temporarily, I drove valve stem packing of the braided type, ⅛ in. thick, between the plate and filler, as shown in Fig. 1B, using a hard wood wedge. This stopped the leak until there was time to make repairs.

The trouble was due to the fact that when putting in the new tubular gasket it was not placed properly in the groove, so it was impossible to draw up on the bolts to prevent the leak.

To make repairs on this filter it was necessary to remove the gravel in one instance. When repairs were made, the gravel replaced and the filter put into operation, it was noticed that the filter did not furnish as much water as before. At first it was thought that some of the inlet and outlet valves were not wide open, which, however, was not the case. I thought that perhaps some of the water nozzles were clogged up and decided to remove the gravel again. On opening the manhole I saw at once where the trouble lay: the gravel was replaced in the wrong way. Instead of the coarser gravel being next to the water nozzles the finest gravel was placed next to the nozzles, as shown in Fig. 2, at A. This fine gravel, of course, resisted the flow of water somewhat. After the gravel was reversed, that is, the very coarse gravel next to the water nozzles, there was no further trouble. This trouble was caused by a misunderstanding of orders by inexperienced help.

In still another instance, much gravel came out of the filter when blowing out the sediment between the gravel plate and bottom head of the filter, through the drain valve, C, Fig. 2. At first I thought this gravel came through the opening of some of the water nozzles, which, perhaps, were worn. This, however, was impossible, as the openings in any of the nozzles were not large enough to admit the size of gravel that came out of the drain pipe. By further examination, I discovered that

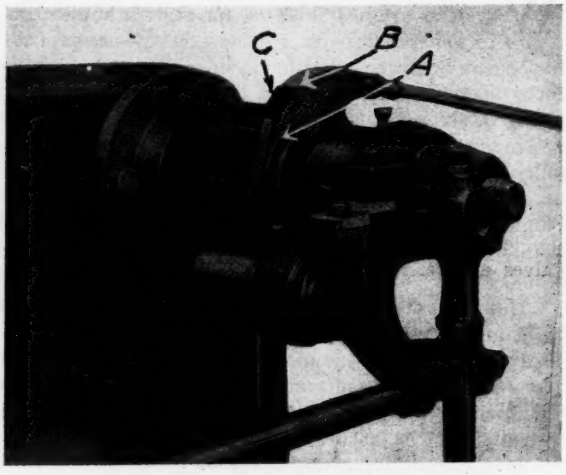


FIG. 4. HOW LEATHER MINIMIZED THE NOISE

on one of the braces holding the gravel plate and bottom head, as shown at BB, the rivet was rusted so badly that the gravel worked through into the space between the gravel plate and bottom head. A new rivet cured the trouble.

REGRINDING A REMOVABLE CHECK VALVE

AT ONE time I had trouble with a ½-in. removable-disc type check valve leaking a little and interfering with the proper operation of the apparatus to which the check was connected. Placing a new disc made matters worse, as the valve seat was cut somewhat. As I had no new valve in stock and no valve reseating machine on hand, I was up against it for a while, until I hit upon the idea of regrinding the seat the same as where the disc and seat are of solid brass or other hard material. I covered the disc with some grinding compound and worked it forward and back for a short time on the seat.

Of course, as the disc was softer than the seat, more was ground off of this than the seat, but the result was a water and steam tight joint. As there is no opening in a check valve of this type, as in regular regrinding type of valve, through which a screwdriver is entered to

move the disc forward and back when regrinding them, I entered the screwdriver through the screwed end of the valve, as shown in Fig. 3, where the end of the screwdriver is bent a little, so as to fit into the disc holding bolt opening.

Regrinding Uneven Valve Discs

Quite frequently we find a new removable disc which has an uneven surface, and where a check valve is in use where there is but little pressure the valve may leak for some time until the disc face is worn to a true surface.

To prevent this leaking, where I find that a new disc has an uneven surface, I place a little grinding compound on the disc and move it forward and back a short time on the valve seat, as in the above case. An even surface is thus secured on the disc and the valve will not leak.

Eliminating a Noisy Valve Gear

At one time I had charge of a Corliss engine where the valve gear was quite noisy, especially when the valves were released by the two parts, A and B, striking together, as shown in Fig. 4. To eliminate this noise I glued a thin piece of leather on, as shown at C. By placing a little oil on this leather occasionally it does the work for months at times, while the gear makes very little noise.

Of course, when placing the leather at this point, the reach rods from the governor must be adjusted again, as the leather tends to make the rods longer, hence the valves are released sooner.

Cost of Packing Friction

By S. C. Horst

THE FUNCTION of packing around a piston rod is to save money by preventing steam from leaking out. It is a plausible function. But there are two general classes of packing—good and bad. Both of them may be perfectly steam tight, yet the one may create much more friction than the other. As a result, the power loss due to this friction may develop into a surprising amount per year. If the packing is a cheap one, it may be demonstrated that the money lost through its use is sufficient to buy a good packing many times over.

A good test for packing is the flywheel test. It is based on the fact that when a flywheel runs at normal speed it contains a constant amount of energy. That energy may be computed by use of the formula

$$E = \frac{WV^2}{2g}$$

where W is the weight of the flywheel rim in pounds, V is the velocity of the rim in feet per second, and g is equal to 32.16.

Now, close the throttle valve of this engine and the flywheel will continue to run for some time. The greater the friction to be overcome per second, the shorter will be the stopping time. The less the friction the longer the stopping time. If there were no friction to be overcome at all, the flywheel would keep the engine running forever, and at the original normal speed.

These things being true, it is clear that a good packing will permit the flywheel to run for a longer time than will a poor packing. Bearing these several things in mind, I have developed a formula that gives the cost of the unnecessary friction per year. The formula is:

$$\frac{\$WV^2N}{17{,}600}\left(\frac{G-P}{GP}\right)$$

where $ = the cost of a hp.-hr. in dollars.
W = the weight of the flywheel rim in pounds.
V = velocity of the flywheel rim in feet per second.
G = the number of seconds required for the flywheel to come to a dead stop after the throttle valve is closed with the good packing in place.
P = the number of seconds required for flywheel to come to a dead stop after the throttle valve is closed with the poor packing in place.
N = number of running hours per year.

For example, if the cost of your power averages $0.013 per hp. per hour; if you run 3650 hr. per year; if the flywheel weighs 3000 lb.; if the flywheel velocity is 5000 ft. per minute, or 83.3 ft. per second; if the stopping time with good packing is 75 sec. and with poor packing 68 sec., what is the cost of the unnecessary friction per year?

Substituting in the formula, we get:

$$\frac{\$0.013 \times 3000 \times 83.3 \times 83.3 \times 3650}{17{,}600}\left(\frac{75-68}{75\times 68}\right)$$

$$= \$77.30$$

One can purchase a goodly quantity of packing for $77.30—enough to last for a number of years. A great deal of good can be accomplished with that amount of money. Some readers may say, "It's an absurd amount. Such a loss due to poor packing is impossible from the standpoint of friction alone. There is something wrong with the formula." The formula, however, is based on good engineering logic, on actual experiments conducted with engines. The writer knows of none better, or this one would not have been given here.—Ice and Refrigeration.

Anent Water Consumption

The recording instruments of the Denver Water Co. show that a few degrees difference in summer temperature cause a vast difference in water consumption.

To give a concrete example: On June 29, 1919, at a temperature of approximately 90 deg. F. 78,090,000 gal. of water were used in the city, while on the same day this year, at a temperature averaging about 75 deg. only 56,770,000 gal. were used, a difference of 21,320,000 gal.

Other records show that the average consumption of water a day for June this year will average 20,000,000 gal. less a day than for the days of June, 1919. The average temperature for June, 1919, was 67.6, whereas for June, 1920, it was 65.7.

J. B. Dillon.

One of the essential qualities of valve stem or piston rod packing is elasticity; for this reason, it is seldom advisable to use packing twice—it is likely to score the rod.

Steam Pipe Size and Valve Setting

POWER FOR a certain plant was supplied by a medium speed four-valve engine. Due to changing conditions it was necessary to relocate this engine and it was up to the engineer to take charge of the work.

One of the first things done was to figure the diameter of steam pipe necessary to supply the engine in the new location without undue loss in pressure. This is how it was figured.

The engineer knew better results would be obtained with a receiver separator on the line above the throttle than without. Furthermore this admitted the use of a

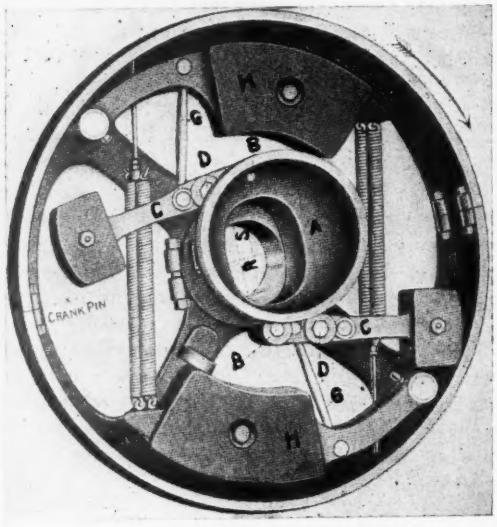


FIG. 1. DETAILS OF SHAFT GOVERNOR

smaller pipe, the difference in the cost of the pipe practically paying for the receiver separator. The horsepower of the engine was 250, and steam per hp.-hr. 28 lb. at 0.25 cutoff. Assumed velocity of steam 5000 ft. per min. $\frac{HP \times W}{60} \times \frac{4}{3} = 156$ lb. steam per min. Area of pipe required $= 144 \times 156 \times 4 \div 5000 = 18$ sq. in. $\sqrt{18 \div 0.7854} = 4.5$ in. diameter pipe required between boilers and receiver.

The engine was moved to the new location and after running half an hour under load, the speed dropped and investigation showed one of the cams of the valve gear to have broken. This was taken off and repairs made with an acetylene torch.

Figure 1 shows the governor and Fig. 2 a section of the cylinder. Little means of adjustment is provided on the eccentric rods to equalize the rocker-arm's travel, but what there is should be taken advantage of and the rocker arms made to travel an equal distance each side of their vertical center lines when their eccentrics are turned around on the crank shaft from one dead center to the other.

Having accomplished this, remove the governor springs from their case, taking careful measurement of their length. With the crank on dead center, turn the governor case around on the shaft to bring the eccentric on the opposite side of the shaft from the crankpin. Now continue to turn the governor on the shaft until such a position is found that when the eccentric is moved across the shaft no motion is transmitted to the eccentric rod. Then secure the governor to the shaft. Turn the crank

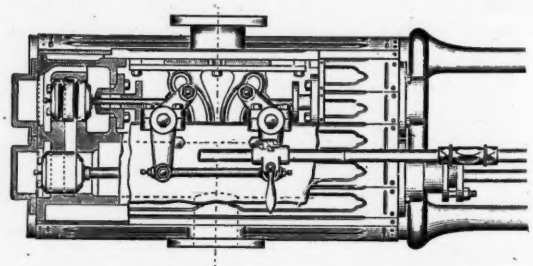


FIG. 2. VALVE GEAR OF FITCHBURG ENGINE

to the other dead center, move the eccentric back and forth across the shaft and see if any motion is given to the eccentric rod. If so, relocate the governor on the shaft to reduce such motion one-half. The governor is then to be secured to the shaft by tightening the clamping bolts in the hub of the governor case and spotting the shaft with a drill after removing the large setscrew in the hub. The setscrew is to set up solid.

Put the springs back in the governor and adjust their length to the same as when removed, making the length of the springs that go through the counterbalance weight that is nearest the springs 0.75 in. shorter than the length of the other springs.

Put the latch of the steam hook in the middle of the slot it travels in and clamp it securely by its lever, making the travel of each wrist crank equal, if not already so, by adjusting the right and left connection between the two.

Put the crankpin on the head end dead center and slide the steam valve stem in or out of the cam until the head and steam port is opened up the desired amount for lead The setscrew in the cam is then tightened to secure the stem in position. Turn the engine over to the crank end dead center, and make the same adjustment for the crank-end steam valve.

Turn the exhaust eccentric around on the shaft in the direction the engine runs and equalize the exhaust valve

travel in relation to their ports. To do this, it is sometimes necessary to square off some of the shoulders the valves are to seat against on the rod, or perhaps it is necessary to insert shims between the valves and shoulders to get the best results.

Having evened up the exhaust valve travel, put the crank on the dead center and measure off on the guides about 0.875 of the stroke or at whatever place it is thought compression should begin, then turn the engine over in the direction it runs until the crosshead reaches the mark. Turn the exhaust eccentric ahead until the exhaust valve on the end the piston is approaching closes the port and fasten the eccentric to the shaft. Then turn the engine to the other dead center and repeat, and make any changes necessary equal to 0.5 the difference. Tighten up the eccentric setscrew permanently.

It is to be remembered, that while this engine is controlled by a shaft governor, it has constant compression and any change in cutoff does not affect the point in the stroke when release or compression begins or ends.

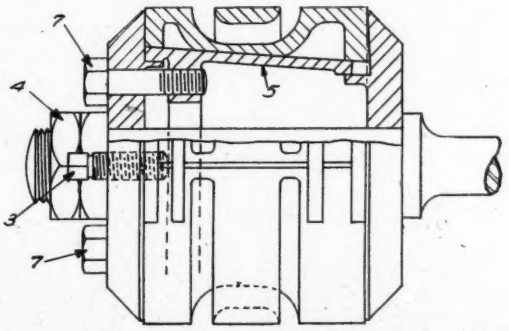


FIG. 3. SECTION THROUGH STEAM VALVE

After starting the engine, it will usually be found necessary to maintain a little friction between the eccentric and governor hub to act as a dashpot to prevent undue sensitiveness.

Indicator cards should be taken as soon as the engine is started and the valve setting changed as the conditions may require. More tension is put on the governor springs to increase speed or less to reduce speed.

Figure 3 shows the steam valve in elevation and section. Adjustment for wear is secured by loosening up nut, 4, enough to let the cone, 5, be free to move; then loosening up the bolts, 7, and turning the setscrews, 3, in until the valve has expanded to a good working fit as determined by working the valve forward and back with the starting bar. The exhaust valves are adjusted in the same manner. It is always desirable to make these adjustments as soon as possible after stopping, as the parts are heated and the expansion is present under what are practically running conditions. A little attention to the valves will keep them reasonably tight indefinitely.

RECEIVER.

That License Law

IN LOOKING through the leading engineering papers I see considerable being said in regard to the proposed bill to license stationary engineers by the U. S. Federal Government. A better bill could hardly be passed for the protection of those who earn their living in the power plant. But talking and writing about it surely won't get us anywhere. What won the great wars of this world? Certainly talking and writing did not. Action is what's needed.

Recently I saw something that made me feel the genuine need of a license law. A boiler was washed out for the first time in 10 mo. It is a small 40-hp. shell boiler used in a milk and ice cream plant. It runs seven days a week and averages 16 to 18 hr. a day. The engineer in charge asked the owners for a chance to wash out at night, but the owners said, "No." So one night after work, the boiler was washed out. Nearly 100 lb. of loose scale was removed from the bottom sheets. The pipes from the column to the cross and from the cross to the water space were so badly plugged that it took about 15 min. for water to show. A new cross was put in with brass plugs. A small rod had to be driven into the boiler-head pipe before a screwdriver could be used for a scraper. The next thing was to clean the combustion chamber. In so doing, a crow that holds the back plate in place was found to be in two pieces in the soot. A piece hit with the back of a pocket knife broke.

Give us the protection of a license law that will give the engineer the "say so" in his plant. Ninety per cent of plant owners don't know enough of boilers to say so. Have a license law providing a heavy fine for the employer of the engineer holding such license to interfere with the necessary maintenance of the plant.

Another bad practice is the employing of engineers and requiring them to do work outside their plant during running hours. This is a dangerous practice and the sooner stopped the better. Who knows, if he leaves his plant to do some work about the premises, what he will find when he gets back. You don't see many licensed marine engineers doing odd jobs about their ships, so why should a power plant man be expected to do so? In my opinion, no engineer should be eligible for a U. S. stationary license who has not had at least 3 yr. operating experience and who does not understand the plain rules of mathematics and read and speak the English language.

Let the younger generation of future engineers study and read and remember what they learn, and they will get there sooner.

R. G. SUMMERS.

Cutting the Speed of Pumps

ON PAGE 761 of the Aug. 1 issue, I notice the article by Clement Corey under the above caption.

While I do not wish to advise that air pumps on condensers be speeded up to a reckless rate, yet I would not presume that this extra speed would greatly, if any, increase the fuel consumption. While the engineer was exhibiting the various instruments, no doubt he showed the visitor the open feed-water heater and told him that the exhaust steam from the various pumps was used to build up the temperature of the boiler feed water.

If steam was escaping to the atmosphere, after the boiler feed-water thermometer said 212 deg. F., then I should say ease up on the pumps, if possible, remembering all the while that more or less air is being delivered to the condenser and the pump has got to take this air away as well as the injection water and water of condensation.

If the load is fluctuating, it is possible the air pump may be speeded to meet the peak condition, even though while the visitor is present only normal load obtains.

Quite often vacuum is raised by throttling injection and speeding pump.

I wouldn't give the engineer so much of a call for a speedy air pump as I would for oil cups running too slowly.

We are getting away from the reciprocating pumps more and more and it is a case of watching the injection on our new turbine installations. The speed of the pump running at perhaps 600 r.p.m. and prime mover at 2400 r. p.m. is not so easy to count as the slow-moving reciprocating unit, but its operation is just as imperative and I prefer full speed on this unit as on the other.

On page 767, E. C. W. brings up a good point to remember. He got burnt by the breaking of a damper chain. Had the chain been used to close the damper, no blowback would have been experienced.

When operating forced draft apparatus the uptake should be closed by pulling the chain (if chain is used) and a weight should open it. I have made this change at different times and believe that "safety first" demands it.

E. C. W. would not fire spasmodically even with forced draft, if uptakes, fan and fire bed were regulated properly. If the fan is allowed to stop for periods of 5 to 10 min. it shows that there are too many units on the line; cut out one.

I have had forced draft on units of 150 hp. and on units of 1000 hp.; in both cases, we tried to maintain approximately a balanced pressure in the fire box and when we did so the CO_2 reading proved our theory to be correct.

The man who hand-fires the plant wants more units on the line so he can have longer breathing spells. The man who fires with the stoker, has a CO_2 machine and is trying to save fuel, wants as few units on the line as possible.

TOM THUMB.

Eliminating Vacuum Troubles

IN MANY reciprocating engine plants using jet condensers, difficulty is experienced in maintaining the vacuum at 25 in. This trouble, however, is not constant, but turns up from time to time. A condenser with its valves in good condition, the water piston in proper shape, and with the required amount of injection water, should be able to do the work. If trouble develops, proceed as follows:

When the vacuum drops an inch, examine the suction well to determine whether the screening is dirty. If clogged with rubbish or dirt it should be cleaned properly, noting afterward whether or not the vacuum has increased.

With cross-compound engines, the most important place to look is at the exhaust valves on the low-pressure side. I have seen cases where the gland came entirely off, due to the fact that it had been allowed to work loose for some time. This, of course, admitted air into the cylinder and destroyed the vacuum.

The small leaks are important and unless close watch is kept, will cause trouble. If a mercury column is used the difference may be noted imediately after tightening the glands.

While these hints are known, no doubt, by many engineers, there are others who may not know them and who think the trouble is in the condenser.

CLEMENT CORBY.

Pressure Records Show Neglected Flues

THE TWO charts shown here are a good example of neglecting to blow boiler tubes. They were taken from a plant of which I once had charge. In the case of Chart No. 1 the boilers were not blown for a week, and while nearing the last half of the week the fireman had to work continually to hold steam. While ordinarily he burnt a mixture of ½ screenings and ½ New River, he now found it necessary to burn ⅓ screenings to ⅔ New River, and even then, he told me, he thought he would lose the steam.

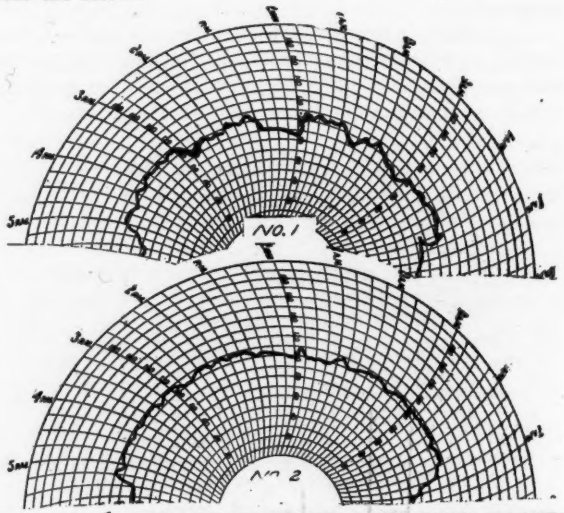


CHART NO. 1. THE DAY BEFORE THE FLUES WERE CLEANED
CHART NO. 2. AFTER THE FLUES WERE CLEANED

All this time he reported that the tubes were blown every night after he was through work I had a way of knowing when they were cleaned, but I said nothing about it. At the end of a week, it was almost impossible to get enough steam, so the tubes were blown and No. 2 chart shows the difference.

After that it was easy to burn ½ screenings and ½ New River. It is hardly believable that a fireman would do a thing like that when it takes only 7 min. to blow a boiler and also saves a hard day's work.

A. C. WALDRON.

JUDGE of Superior Court at Cincinnati has ruled that employers operating open shops may rightfully bargain with those whom they hire not to become members of any labor union or to have dealings with agents of such unions with a view to joining a union, and that agreements to that effect are valid: "Any employe has the right to agree with his employer that he will not only refrain from joining a union during the term of employment, but he may also lawfully agree . . . that he will not have any negotiations or communications with others as to such employment during the period that he is so employed." Strikers are enjoined from persuading workers under such contracts to join the unions.—Industrial News Survey.

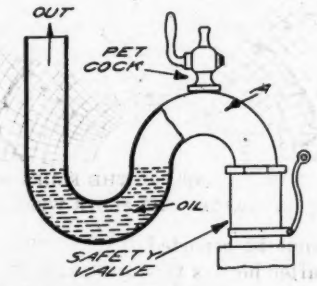
An Ammonia Leak Detector

IT COMMONLY occurs in connection with refrigerating machinery that safety valves, joints, stuffing-boxes, etc., develop leaks that are detected with difficulty.

Herewith is the sketch of a device designed for the purpose of detecting leaks wherever it is possible to trap the leakage.

When ammonia escapes through the safety valve, it is trapped in the chamber A, causing the oil to shift over toward the left. A slight pressure will be created in chamber A depending upon the difference in oil level in the two legs. To test for tightness, the operator then simply opens the pet cock and he will be able to hear or smell the escaping ammonia which had been trapped.

This design does not interfere in any way with the operation of the safety valve. Should the valve open, due to excessive pressure, the oil would simply be blown out.



ARRANGEMENT OF PIPING TO DETECT AMMONIA LEAKS

Any non-freezing liquid that will not absorb ammonia can be used in place of the oil if desired.

N. G. NEAR.

Unique Form of Scriber

THE SCRIBER as a tool for marking lines upon steel and other metal surfaces, is used so extensively by machinists, workers in automotive shops and other factories, that a special interest attaches to any improvement that will render it easier to handle in use. The regular pattern of scriber made out of a round rod of hardened steel, has the drawback, when long or curved lines are drawn, of shifting its position slightly in the artisan's hand (which is always more or less greasy, thus making it harder to hold in one position) the line being drawn wider at some places than at others, due to the point of the scriber wearing unequally on different sides.

In laying out templets, which have to be filed to a line, this interferes to some extent, with the accuracy of the filer's work and slows the latter down. The scriber devised by the writer is easier to hold straight in any position and it makes lines of equal width; it is only necessary to hold the handle in one position, either a vertical or a horizontal one, to ensure the line drawn having the same width.

Get a piece of 5/32- or 3/16-in. round rod of high-carbon tool steel of the desired length. Heat it to a cherry-red color and bend the hot end around an iron rod in a vise. Cool in water; place the end where the point is to be, in the fire, until it is red hot. Quickly remove with a tongs and rapidly draw the end to a point with a hammer. When cool, grind it on an emery wheel until it is as round as possible, finishing any inequalities with a file or oil-stone; making a needle taper toward the point. Heat the business end to a cherry-red and quench in water. Try the point for hardness by making a scratch on a flat steel plate. If the metal contains too much carbon, the point will crumble; if just right, the sharp point will hold. Should the former condition prevail, sharpen the point again and heat it to a cherry-red and plunge it into cold water, leaving some

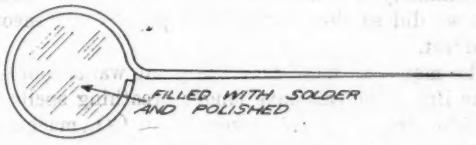


FIG. 2. SCRIBER READY FOR USE

heat in the upper portion of the rod. Quickly rub one side, near the point, with a piece of emery cloth tacked upon a block of wood; watch the colors extend to the point, when a straw color is reached, dip into water.

The next thing to do is, to fill the handle with solder. Dip loop in a chloride of zinc soldering fluid, which is made by putting pieces of sheet zinc into hydrochloric acid, until the latter will not dissolve any more. The above solution is a good flux for uniting articles of iron, steel, copper and brass, but should not be used for electrical work. After dipping, lay the loop upon a flat board and holding a hot soldering copper against a bar of solder, run sufficient of the latter in, until the handle is filled. Also lay the hot copper over the sides of the wire loop, as both the solder and the metal require to be hot to do a good job. While soldering, cover the point with a wet cloth to prevent its temper being drawn. Remove all traces of acid by washing thoroughly in water; then grind surplus solder off the handle, brighten everything with emery cloth and oil to prevent rust.

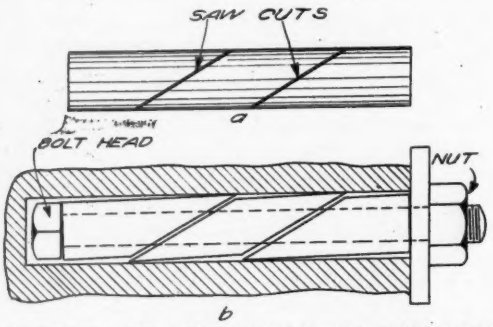
In using a scriber in making templets, the writer has found out by experience, that a line drawn on a copper-coated surface shows more clearly than does one made upon a blue chalk covered plate. Free one side of the plate from grease and dissolve a few crystals of copper

sulphate in water in a bottle. Use a round brush to put it on the plate, which will instantly turn copper colored. Rinse and dry the plate carefully; it is then ready for use. Sulphate of copper is a poison, so be careful in handling it.

W. S. STANDIFORD.

Expansion Bolt Kink

A SIMPLE way of securing a bolt in a brick or concrete wall is shown in the illustration. A piece of pipe of the desired size and length is cut, as shown at A. A bolt is then slipped through the three pieces of pipe and the combination is inserted in the hole, the head of the bolt entering first. B shows how the pipe expands and how the sharp edges grip the concrete or brick when the net is drawn tight. This kink is not original, but is worth passing along, as it can be made from stock on



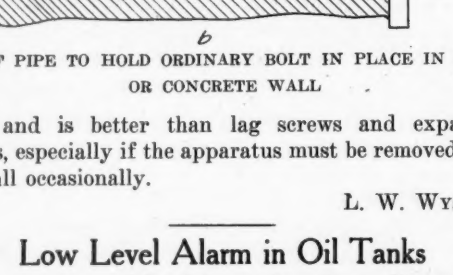
USE OF PIPE TO HOLD ORDINARY BOLT IN PLACE IN BRICK OR CONCRETE WALL

hand and is better than lag screws and expansion sleeves, especially if the apparatus must be removed from the wall occasionally.

L. W. WYSS.

Low Level Alarm in Oil Tanks

ON A RECENT visit of inspection, the writer saw an ingenious low level device designed by the storekeeper of a large plant, who found that frequently the men would allow the supply of the various oils in the different barrels to go to the extreme low level before ordering. This, in these days, is a very undesirable circumstance, considering the delays usually incident to securing supplies.



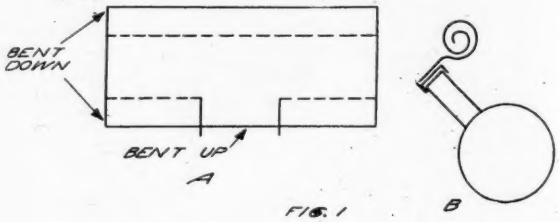
METHOD OF FITTING THE SWINGING SUCTION PIPE

The oil barrels were all served with vertical pumps, and this engineer provided a reserve storage of 15 in. in the bottom of each barrel, in the manner shown in the illustration. Instead of running the suction pipe straight to the bottom of the barrel, he broke it off about 18 in. from the bottom, at which point he inserted two elbows and then another piece of pipe, about 15 in. long. When the barrel was filled, the loose end was drawn to a level about 15 to 18 in. above the bottom of the barrel, from which point the suction was taken. When the oil fell to this point, the suction was, of course, lost. The operator was reminded that another barrel of oil was needed, though, by pushing down the swinging end of the suction pipe, the lower 15 or 18 in. of the barrel was made available to tide over until the new supply was received.

M. A. SALLER.

Three Time-Saving Kinks

HAVING TROUBLE with sparking brushes, on account of the springs not holding the brushes in the proper place, I made small clips of sheet iron to fit over the tops of the brushes. Taking pieces of sheet iron ⅜ in. wider than thickness of brushes, and the same length as the width of the brushes, I bent them to channel shape



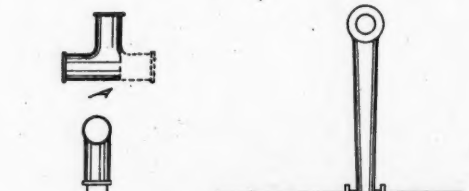


FIG. 1. TIN CLIPS TO HOLD BRUSHES IN PLACE
FIG. 2. EMERGENCY ROCKER ARM REPAIR
FIG. 3. IMPROVEMENT ON RECIPROCATING PUMP GEAR

and bent back part of one side as shown in Fig. 1A. These clips kept the brushes in position.

Breaking of the rocker arm on a Hooker pump was speedily repaired by means of a ⅜-in. tee and a piece of ⅜-in. pipe. One side of the tee was cut off as shown in Fig. 2A, and the pipe cut to the proper length was screwed into the tee. The pipe served as the rocker arm and the tee as its bearing, as in Fig. 2B, until a new arm could be secured.

We had trouble with a Worthington circulating pump. The piston would rotate occasionally and throw the rocker arm out of the crosshead. We removed the crosshead and in its place we fastened a short nipple carrying at each end part of a flange union, as shown in Fig. 3. This effectually prevents the crosshead from slipping out.

E. G. MUELLER.

Arthur and I

By Daniel W. Maguire

I DON'T SUPPOSE I'll ever forget the days when I broke into this game, nor the disciples of the engine room who helped me get a start; nor how they worked hand in hand with me. No, indeed! I'll never forget my first days in the power plant.

I could write a book, it seems, about my early experiences, and I could fill these pages with praises of the men who helped me get my start, but space will not permit.. However, I am going to tell of one, Arthur, as I shall call him, and how he started me along the road, and the interest he took in me. I wonder where he is now. A better man than he never crossed my path.

He was a big, broad-shouldered man with blue eyes and curly hair, and he had a winning way that made all men respect him. I first made his acquaintance at the tannery, when he came there as engineer.

His duties were many at first. He was his own fireman, oiler, coal-passer, etc. In short, to use the slang expression, he was the whole cheese.

After a while his duties increased, so he appealed to the super. for help and his request was granted. I was the one chosen to fill the order. I left my machine in the shop and went to the boiler room as fireman.

Memories of the shop with its monotony and tiresome work soon faded from me and life in the boiler room took on a new meaning. I soon learned, under his never-tiring kindness, the why and wherefore of all the numerous pipes, valves and fittings. I learned how to use the various engine room equipment, and he loaned me books —for I loved to read—on power-plant practice.

Then, one day, something happened that changed my plans for the future. Arthur asked me to go for a license.

"You'll get it, Mooch"—that was the name he jokingly gave me—"I'll bet a dollar you'll have a second-class license the first shot."

I hardly knew what to say. I started to make excuses, but that did not go with him.

"You see, if you don't try for one there'll be the dickens to pay if the inspector learns that an unlicensed man is firing here," he warned. "Send for your papers now, make 'em out when you get them, send 'em in, and then wait for results."

So I sent for my papers, in the meantime studying hard under his tuition. Finally my papers came. I filled them out and sent them in, and then Arthur, hearing of another job where a fireman was needed, recommended me to the chief. I got it and worked about a week before getting my notice for examination.

Finally the day came for my examination, and early that morning I left for the city, 12 mi. distant, where the examiner's offices were located.

I need not go into details of this place. Most of you are, I think, familiar with such an office. At any rate, after less than an hour's examination, I became the owner of a second class fireman's license.

It was two days later before I saw Arthur again, and when I told him of my luck he remarked: "What'd I tell you, Mooch? Now use it well. Aim as high as you can and then work as hard as you can to reach your goal."

But I was very young—only eighteen—and just like many another young fellow, I knew it all. That proved to be my undoing. I lost my job.

So back to the tannery I went as Arthur's fireman once more. He was very good to me, but still he constantly gibed and taunted me about my first failure. Then after a month or more he heard of another job. Needless to say, I got it. I worked there something like three or four months and in the meantime Arthur had changed his job, too. He went to a large city as watch engineer in a large building.

Then again I lost my job. I was in a sorry plight. I went to Arthur once more and poured out my story.

"Well, you big nut! What's the matter anyhow? Get onto yourself." he exclaimed.

I next got a job in a hospital as fireman and worked there until Arthur, then in another plant as chief, came to me and asked me to go with him awhile.

"I need you, Mooch. I'm only around these parts for a short time more, then I'm leaving. Come with me and when I'm done with you I'll see that you have another job."

So after a week's notice, I left the hospital and went to Arthur, staying there 'til that day I shall always remember—the day we said "good-bye."

I've worked in three plants since, but have never seen him, though the folks have told me he had been in town inquiring for me; and, come to think of it, I received one letter from him asking me to come to him. But I've got a good job; been here almost two years now. Still there are times when I long for him, and I wonder whether I shall ever see him again.

To young engineers, the story of Arthur's interest in young men who are turning their feet toward the path that leads to honorable and enduring success should prove instructive as well as interesting.

Those who have been close to him, whether as associates, managers, or subordinates, have always had a good word for him. I know! They've told me.

So here's to Arthur—the finest boss I ever knew!

Witness His Mark

An old darkey, entering the store of a rubber stamp maker, said: "I'se want ter gits me a rubbah stamp."

"All right, Uncle. For what purpose?"

"Jist mah signature."

"All right. Now, write your name on this slip, just as you always sign it and we will make it for you."

"I'se declares, Boss, I can't write."

The dealer was a good-natured fellow, as well as a good salesman, so he asked for the name.

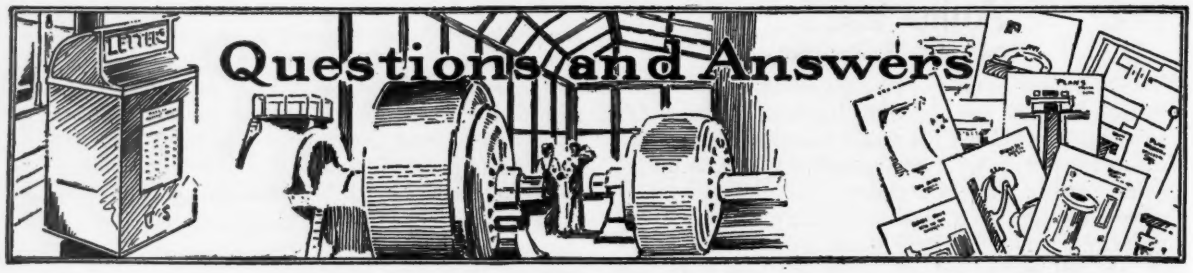
"Sam Thompson."

The dealer wrote Sam Thompson in a plain hand, then asked the darkey to try to imitate it.

After a hearty tussle the old fellow handed over the card, with a pretty fair imitation, but at the left-hand corner he placed a large "X"

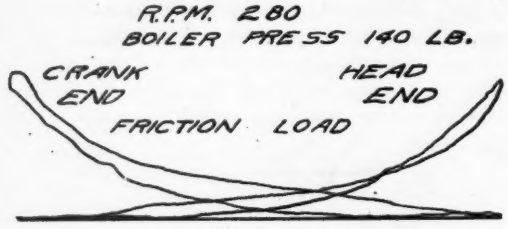
"You did splendidly, Uncle, but what is that "X" for?"

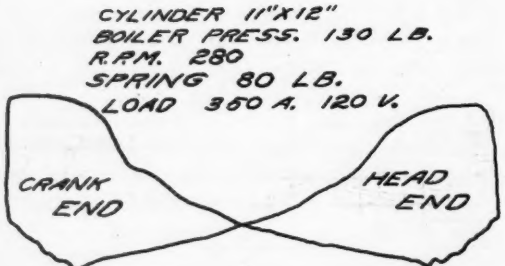
"You sees, Boss, dey always tells me to make mah mark when I'se signs the pay roll. Jist wanted to make it complete.'



Indicator Cards for Criticism

THE ACCOMPANYING diagrams were taken from a high-speed, single-valve, automatic Skinner engine. This engine has been in operation for 10 yr. operating about





CAN YOU SUGGEST ANY IMPROVEMENTS?

18 hr. a day. It is running smoothly. I would like to have the readers criticise these cards and suggest improvement, if any. J. F.

Why the Current Fluctuation?

IN THE factory power plant with which I am connected is an air compressor driven directly by a synchronous revolving-field motor.

The compressor has a low-pressure cylinder, 27 in. in diameter and 21-in. stroke; and high-pressure cylinder is 16½-in. diameter and has a 21-in. stroke. Cranks are set on quarter. Capacity is 2047 cu. ft. free air per min., at 180 r.p.m. (constant speed). Output is regulated by means of four-step clearance controllers.

The motor (with belted exciter) is 400 hp., 3-phase, 60 cycle, 2200 v., 85 amp., 180 r.p.m.; and has 40 poles. It is without a flywheel. It has a fractional pitch star connected winding. A squirrel cage for starting is included.

In operation, at full load the a.c. current at 100 per cent powerfactor varies from about 85 to 90 amp. with every revolution, or about 6 per cent above minimum. The per cent variation is about the same at 0, ¼, ½ and ¾ loads. The supply voltage remains very nearly constant.

The ammeters in various feeder circuits also show a continuous slight swing in step with the speed of compressor.

With this compressor on the line, a 50-kw. synchronous motor-generator—without damping arrangement—hunts so seriously as to prohibit operation of the latter.

Cards taken from the cylinders indicate the valves to be working properly, and work done at each cylinder end about the same.

Can anybody suggest a reason for this continuous current variation, and a probable remedy?

C. F. B.

Indicating Diesel Engines

IN INDICATING the Diesel and other oil engines of more than one cylinder, would you indicate each cylinder and get the average of each or would you add them as they are indicated? What springs are generally used? How do you know what spring to use? Can a regular steam engine indicator be used and will it stand the heat? As the pressure is only on one side of the oil engine piston, how can a piping arrangement be made to connect the indicator? I consider the best way is to put it on as close to the cylinder as possible.

DIESEL.

Criticism of Corliss Cards

WHEN I looked at the Corliss engine diagrams submitted by E. R. and published in the July 15 number of Power Plant Engineering, and saw the steam lines as straight as if drawn with a ruler and ending in a sharp point of cutoff, I became suspicious.

When I read the data on the diagrams and found that he was using a 50-lb. spring with 150 lb. boiler pressure and an 8-lb. spring with 15 lb. receiver pressure and 24 in. of vacuum, I felt that my suspicions were justified.

The springs used in both cases are altogether too light.

With the high-pressure spring used and full boiler pressure in the cylinder, a diagram 3 in. high would be the result and with the low-pressure spring used, a diagram nearly 3⅜ in. high would result if the indicator was designed to take such high diagrams; it is my experience that they are not.

Either the springs are compressed the limit or some part of the mechanism between the indicator piston and

the pencil points interferes with the indicator taking a true diagram. The remedy is heavier springs in both cases.

The following is from the book of instructions of a prominent indicator manufacturer: "The strength of spring that should be used for indicating an engine depends upon the maximum steam pressure to which it will be subjected; it should be of such strength or number that the diagram will not be over 1¾ in. high. The proper spring in any given case may be found as follows: Divide the boiler pressure expressed in pounds, by the desired height of the diagram, expressed in inches, and the result will be the number of the spring required.

For the high pressure $150 \div 1\frac{3}{4} = 85$ spring, or the nearest strength spring to be had, probably an 80.

For the low pressure, add the receiver pressure expressed in pounds and the vacuum expressed in pounds and then proceed as for the high pressure.

24 in. vacuum equals 12 lb. nearly.

12 lb. vacuum and 15 lb. receiver equals 27 lb.

$27 \div 1\frac{3}{4} = 15$ spring, or the nearest strength spring to be had, probably a 16.

The high-pressure diagrams both show late release and compression.

The low-pressure, crank-end diagram shows late release, the full benefit of the vacuum not being realized until the exhaust valve is about to close for compression again.

Diagrams taken with the proper springs would give much better looking compression curves.

JOHN A. MURDOCK.

The Need of Compression

WHICH is the more economical, to compress exhaust steam at the end of the stroke or to run the engine without compression and admit more live steam through the steam valve?

2. Which type of heater will give the hotter water, an open or a closed heater?

3. Can an engine equipped with a Rites inertia governor be made to run a trifle higher speed at full load than at no load?

4. Given a stay bolt pitch of 5 by 5 in. another pitch of 6¼ by 4 in., which would you use and why?

S. T. J.

ANSWERS

COMPRESSION of the exhaust steam at the end of the stroke uses power and compression is, therefore, generally kept as low as possible consistent with smooth running of the engine. The engine should always have a certain amount of lead and the most economic arrangement is the correct proportion of compression and lead.

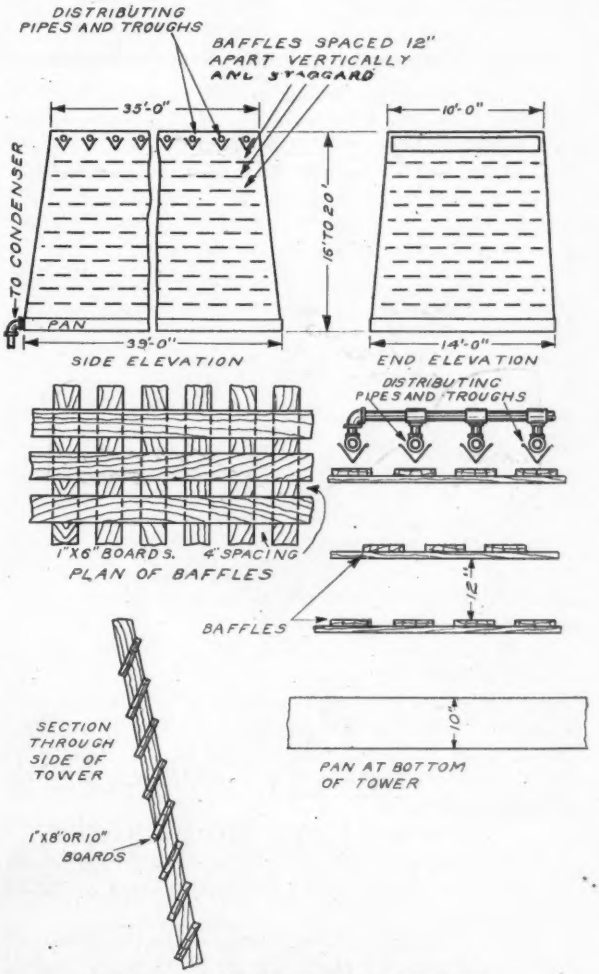
2. The closed heater delivers water at a higher temperature than the open heater for the reason that the open heater is at atmospheric pressure and the steam used therein cannot be at a much higher temperature than 212 deg. F. The water, therefore, can be heated only to say a maximum of 200 deg. The closed heater on the other hand, can be submitted to whatever pressure is necessary in order to use high-temperature steam. Water can easily be heated to the boiling point or higher in a closed heater.

3. An engine equipped with a Rites inertia governor can be made to run slightly over speed at full load by moving the pin which fastens the spring to the inertia arm closer to the point at which the inertia arm is pivoted.

4. Stay bolts pitched 5 by 5 in. are preferable to those of 6¼ by 4 in. pitch for the reason that there is a shorter span between the stay bolts than there would be where they are pitched 6¼ in. in one direction.

Cooling Tower Structure Details

I WOULD LIKE to ask through your consulting engineers information in regard to building a cooling tower. We are uncertain just how to build it. Our back pressure is from 16 to 30 lb. and our high pressure goes to 240 to 265 lb.; our water goes to from 90 to 104 deg. F. in the summer. Our plant requires 350 gal. of water per minute.



DETAILS OF COOLING TOWER STRUCTURE

In warm weather it has to do its best to get tonnage on account of the water getting too hot on the ammonia condensers and cooling the distilled water for the ice cans. If you can give us any light on any kind of water towers, it will be gladly received. J. J. B.

A. In response to your request we are enclosing herewith a number of sketches showing details of a cooling tower. Not having sufficient data to enable us

to determine the exact rating of your cooling tower, we have used as a basis for our calculations the area of 1 sq. ft. per gallon of water to be cooled. It must be borne in mind that the location of the tower with respect to freedom of circulation of the air and the average velocity of the wind would have much to do with its successful operation. It is probable that one gallon of water per square foot would be about the extreme size that would be necessary, and the chances are that with a very favorable location you would be able to reduce the size somewhat.

Should you desire to go into this subject more deeply, we would suggest that you write the Secretary of the American Society of Mechanical Engineers, 29 West 39th St., New York City, who would probably be able to supply you with a copy of a paper on cooling towers which was presented by J. R. Bibbins some time during 1909.

Piping Required for Cold Storage Rooms

WE ARE fitting up six cold storage rooms for holding berries in barrels at a temperature of 15 deg. F. Each room contains about 50,000 cu. ft. of space. We have installed in each of the six rooms two separate direct-expansion coils, each made up of approximately 1660 running feet of 2-in. pipe, making about 3320 ft. per room, or a total of approximately 20,000 ft.

What size pipe should be used to connect up these 12 coils with the main liquor line in order to supply these coils with the necessary amount of liquid ammonia in order to hold the above temperature? And how do you figure this?

These rooms are in a modern, well insulated concrete cold storage building. E. E.

A. By referring to given tables, the answer can be had without going into details; but the writer asks how to figure this, which requires details.

Each cold storage room containing 50,000 cu. ft. will require about 15,000 sq. ft. of exposed walls The dividing walls, of course, will not be exposed when the two adjoining rooms are being used.

Good insulation of 4-in. cork will lose about 2 B.t u. of refrigeration, per square foot, per 24 hr., for every degree difference in room temperature and outside temperature. Assuming the average difference in temperature between the inside and outside of the room is 50 deg. F.. then the total loss in refrigeration for 24 hr. for six rooms will be:

$$6 \times 15{,}000 \times 2 \times 50 = 9{,}000{,}000 \text{ B.t.u}$$

Now, allowing for the refrigeration loss through doors and light, add about 15 per cent more, making a total of 9,450,000 B.t.u.

One ton of refrigeration is equal to the latent heat of one ton of fusing ice at 32 deg. F. The latent heat of 1 lb. of fusing ice is 144 B.t.u One ton, or 2000 lb., is equal to 2000 × 144, or 288,000 B.t.u.; 9,450,000 divided by 288,000 equals 32 8, the number of tons of refrigeration required for the six rooms.

The latent heat of evaporation of 1 lb. of liquid ammonia at 15.67 lb. gage, zero degrees Fahrenheit, is 555.5 B.t.u.

If the liquid could be delivered to the rooms at zero degrees Fahrenheit then the total 555.5 B.t.u. would be available for the rooms; but the liquid is generally delivered to the rooms at about 80 deg., hence every pound of liquid ammonia used in the rooms has to be lowered from 80 deg. to zero deg. F.

555.5 B.t.u. less 80 B.t.u. leaves 475.5 B.t.u. delivered to the rooms; for the specific heat of liquid ammonia at 80 deg. F. is one.

There should be about 10 deg. difference in the temperature of the evaporating liquid and the temperature the rooms are to be kept.

The number of pounds of liquid ammonia necessary is equal to 9,450,000 divided by 475.5, or 19,852 lb.

The amount of liquid that can be discharged from a given orifice can be calculated by the formula:

$$W = 62.4 \times c \times \sqrt{2gh} \times a$$

Where W = weight in pounds; 62.4 lb. in one cubic foot of liquid; c = constant = coefficient of discharge; g = acceleration of gravity per second; h = height of head; and a = area in square feet of orifice.

To consider this formula for calculating the size of pipe, we would get a very small pipe that would not be practical to install. Hence we select the most practical size for this purpose. A ⅜-in. pipe inside measurement, will deliver all the liquid that one coil can evaporate. The amount of liquid ammonia that can be evaporated from a coil depends upon the difference in temperature between the evaporating liquid and the temperature of the room, and also upon the condition of the outside of the cooling pipes, i. e., whether they are free from ice or not.

To find the area of pipe required to carry 19,852 lb. of liquid ammonia—velocity of liquid to be about 200 ft. per minute, multiply the number of cubic feet of liquid by the number of square inches in a square foot, and divide the product by the velocity in feet per minute; 62.4 lb. equal 1 cu. ft. of liquid ammonia; 19,852 divided by 62.4 equals 318.1 cu. ft.; 318.1 divided by (24 × 60) equals cubic feet delivered per minute, or 0.228 cu. ft.; 0.228 multiplied by 144 and the product divided by 200 gives 0.164 sq. in. the size of pipe necessary; 0.164 divided by 0.7854 gives diameter squared of the pipe, which is equal to 0.209.

The square root of 0.209 is 0.457 in., the diameter of the required pipe; ½-in. pipe is the nearest to this size.

The ½-in. pipe will carry many times this amount of liquid ammonia, but it would be impractical to install a smaller size pipe. W. A. DARTER.

Ammonia Fails to Show in Receiver Glass

I AM RUNNING a 20-ton compression plant, using both systems of expansion. In spite of the fact that we have put in considerable ammonia, I find that this does not show in the receiver glass. We have two brine tanks besides the direct expansion lines. I wish to test the brine (calcium) for ammonia to see if there is where I am losing it.

This is a creamery and ice cream plant combined. I can lower the temperature of the ice cream hardening room down to 10 deg. below zero, shut all expansion valves and hold this temperature practically all night. The only time I can see any liquor is when I purge back and the minute I open the king valve, away she goes.

But I know it is in the system because I can hear it go through the expansion cocks. In the ice cream hardening room, the ammonia passing through the coils makes a sound similar to the swishing back and forth of water. Why is this?

The compressor we use is a double-acting horizontal electrically-driven machine. One end takes care of the ice cream and the other end cares for the milk plant Both ends are connected by an equalizer. When the milk plant coils are working hard and also the ice cream rooms, I get a nice freeze back on the ice cream end which is the rod end, and you know what that means, especially with metallic packing. Should this equalizer pipe which is smaller than the main suction pipe be in the line? It looks to me as if at times it put all the work on one end of the machine. One of our brine tanks has a rigging in it like a small tubular boiler, the brine going through the tubes and the ammonia outside. A suction at the bottom of the inlet for the gas is at the top. This, I believe, should be just the opposite.

R. G. S.

A. It is just as important to have the liquid ammonia show in the glass of the liquid receiver as it is to have water show in the glass gage on a boiler.

The liquid level must be maintained high enough so as to keep the outlet from the receiver completely covered. Nothing but liquid should pass into the liquid line and to the expansion valves.

The glass gage on the receiver may be blocked so that the liquid does not show the true level. If the bottom connection is choked, the glass will show liquid only when the receiver is entirely full. This may be the case in the plant referred to.

See that both the top and bottom connections between the glass and the receiver are not obstructed.

The amount of ammonia passing through the expansion valves should be regulated so that the glass shows that there is at least 2 in. of liquid in the receiver. If this level cannot be held, more ammonia must be put into the system.

"Nessler's Reagent" is used to test brine for the presence of ammonia. This solution can be obtained from the manufacturers of ammonia.

Take a sample of the brine in a glass and add a few drops of the solution. The brine will turn yellow if there is a small per cent of ammonia present; if the amount of ammonia is great, the brine will turn brown.

The coils in the ice cream hardening room are most likely made up of short lengths of pipe and return bends.

The swishing sound is often heard in this kind of coil when the temperature is 10 deg. F. below zero or colder. It is caused by the liquid passing through the return bends.

The equalizing line that connects the two suction lines together should be the same size as the suction lines. The rod end of the compressor should have its suction from the warm rooms instead of from the ice cream plant. Working the rod end on low temperature and low pressure will always cause packing trouble, loss of ammonia, and air, moisture and oil will also enter the compressor at times.

The valve in the equalizing line can be regulated so that a vacuum will not be created in the cold end of the compressor when the back pressure gets low.

The small tubular "boiler" in the brine tank is a brine cooler of the shell and tube type. The brine is circulated through the tubes by means of a pump or agitator.

The liquid ammonia enters at the bottom of the shell and the suction line to the compressor is connected to the top of the shell.

A. G. Solomon.

Massachusetts Second-Class Examination Questions

I recently took an examination for a second-class engineer's license in Massachusetts. Following are the questions asked and the answers I gave:

1. Why cannot a single-eccentric Corliss engine cut off later than one-half stroke by action of the governor?

A. The eccentric of a single-eccentric Corliss engine is set 90 deg. ahead of the crank, plus the lap and lead of the steam valves, providing the valve motion is a direct motion. This brings the eccentric about 113 deg. ahead of the crank. As the engine moves forward the eccentric approaches its center, all the time moving the head end valve open. When it reaches its center (the crank of the engine is not quite at half-stroke) the steam valve has reached its highest point of travel and the steam port is wide open. If the governor does not trip the steam valve before the eccentric passes its center it will not trip it at all, for the valve begins to close and the crabelaw of the valve starts to move away from the knockoff blocks.

2. If a pop safety valve blows down too much, what is the trouble?

A. The valve is adjusted to blow back too much. To remedy this blowback on a certain make of safety valve, a plug is screwed out of the body of the valve, giving access to a threaded ring under the lip of the valve, which can be screwed up or down. Screwing the ring down will reduce the blowback.

3. If you cut off the lip of a pop safety valve how would it act?

A. Cutting off the lip practically makes the valve act like a lever safety valve. With this lip on the valve we get a reaction effect which holds the valve open longer. As the steam issues from the valve it strikes this lip and is turned downward, which gives us the blowback. For a smaller blowback move ring away from the valve lip or give a large opening leading from supplementary pop chamber.

4. What is an equalizer bar?

A. An equalizer bar is used when a boiler has three lugs on each side. The last two lugs on each side of the boiler are connected to a bar and to the center of this bar is attached the rod that goes to the overhead support. The reason for using an equalizer bar is that with three different points of suspension on each side of the boiler it is impossible to get the same tension on all three lugs. By using the equalizer bar, it is possible by connecting the last two to the bar, to get a two-point suspension on each side of the boiler.

5. Which is the stronger—a single-riveted butt joint or a double-riveted lap joint?

A. The double-riveted lap joint is the stronger.

If the thickness of the plate, diameter of the rivet

holes and the pitch of the rivets are the same in the two joints, the deciding factor will be the shearing strength of the rivets. Assuming that a steel rivet in double shear has a shearing strength of 78,000 lb. per sq. in. of cross-sectional area and a steel rivet in single shear has a shearing strength of 42,000 lb. per sq. in. of cross-sectional area and the rivet in both joints has a cross-sectional area of 1 in. Now in the butt joint there is one rivet in double shear, which has a shearing strength of 78,000 lb., and in the lap joint there are two rivets in single shear, which are equal to 2 times 42,000 lb, or 84,000 lb. shearing strength, making the the shearing strength of the rivet in the lap joint the stronger.

6. Which shell do the stays support in a Manning or other boilers having a waterleg?

A. Staybolts are generally put in to keep the inner sheet from crushing but on the larger boilers it serves to support the outer shell as well. The Massachusetts Boiler Rules state that on a boiler with a furnace exceeding 38 in. diameter the stayed surfaces shall be considered flat.

7. How are staybolts put in the waterleg?

A. The holes are reamed to size and tapped by a combination reamer and tap. The staybolts are cut to size and threaded their entire length and screwed into the two sheets and the ends are riveted over.

8. What size holes are drilled in staybolts?

A. The hole drilled in staybolts should not be less than 3/16-in. and should be drilled to a depth of at least ½ in. inside the sheet.

9. If you took off lap of a slide valve what would it do? How would this affect the release and compression?

A. In taking the lap off a slide valve the eccentric will have to be moved back to give the engine its proper lead. This makes the cutoff, release and compression occur later in the stroke.

10. Why does the feed-water enter so high up in a Manning boiler?

A. Having the feed-water enter so high reduces the tendency of the water to lift off the lower tube sheet when the boiler is forced.

11. How does an injector work?

A. Steam enters the injector through a special shaped nozzle at a high velocity, drawing the air out of the suction pipe and the body of the injector and the atmospheric pressure forces the water into the body of the injector. As the steam meets the water it is condensed and imparts its velocity to the water, which is sufficient to overcome the pipe friction, lift the check valve and force water into the boiler.

12. How do you find the total pressure tending to push off the mud drum of a B. & W. boiler?

A. The total pressure tending to push off the mud drum is the total area of the nipples connecting the mud drum to the rear headers times the boiler pressure.

13. On a pop safety valve, does the tension of the spring increase as the valve opens or does it remain constant?

A. The tension of the spring increases as the valve opens. That is why the increased area is put on the valve so that it can overcome this extra tension.

14. If you had a compound engine with a ratio of 4 to 1, what pressure would you carry on the receiver?

A. Absolute initial pressure of the high-pressure cylinder divided by the cylinder ratio gives the receiver pressure.

15. If you raise the boiler pressure, would you raise the receiver pressure too?

A. To divide the work equally between the two cylinders, the receiver pressure will have to be raised.

16. If you had just taken a job and the man leaving told you that the compound engine would race under vacuum and light load, what would you do to prevent it?

A. The steam valves on the high pressure side are leaking steam. The only way to prevent the engine from racing would be to carry a lower vacuum or reduce the boiler pressure until the necessary repairs are made.

17. Name the different types of shaft governors and tell how they work.

A. There are two different types of shaft governors: the inertia and centrifugal.

The inertia type makes use of a heavy inertia bar pivoted to the flywheel of the engine. As the engine speeds up the bar tends to lag behind the wheel and shortens the cutoff and when the engine slows down the bar runs ahead of the wheel, lengthening the cutoff.

The centrifugal type has two arms, on the ends of which are hung heavy weights. As the engine speeds up, the weights fly out, shortening the cutoff; as the engine slows down, the weights move in towards the shaft, lengthening the cutoff.

18. How could you tell whether the engine would race if the load was thrown off or the main belt broke with a shaft governor?

A. With an inertia governor, block the governor out to the stops and remove the steam chest cover. Turn the engine over by hand and note whether the valve opens the port. If the port has not been opened then the engine will not run away.

On the centrifugal governor with a constant lead—as the engine is turned over by hand the valve should just open the port for the lead.

19. What closes the steam valves on a Putnam engine?

A. The steam valves are closed by springs and their own weight; there is a spring for each valve.

20. What prevents the steam from pushing the buckets endwise on a Corliss turbine?

A. The pressure is the same on each side of the wheel. S. T. J.

Appropriate Size Tubing for Draft Gages

I WISH to construct some U-tube draft gages for my boilers. What size of glass should I use?

Where should these gages be placed on a return tubular boiler? I plan to connect one to the ashpit, one over the fire and one to the breeching. Would this be proper? R. G. S.

A. For U-tube draft gages we would suggest that you use the glass tube ¼ in. inside diameter. The locations which you suggest, namely in the stack breeching over the fire and in the ashpit, are good and we do not think could be improved.

Self-Contained Water Cooler

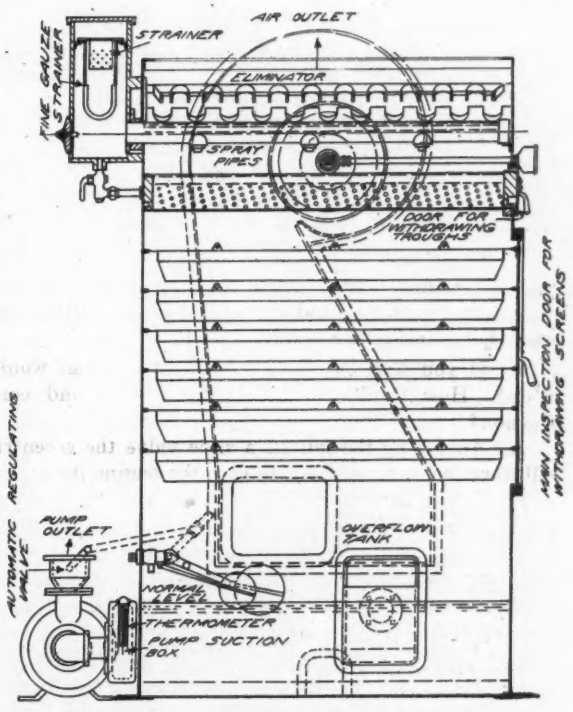
COOLING of the jacket-water of stationary internal-combustion engines is frequently carried out by means of a cooling tank or reservoir, and in such cases the loss of water by evaporation varies from 0.2 gal. to 0.4 gal. per brake horsepower hour. Some 30 to 35 gal. of cooling-tank capacity is required per brake horsepower. With large gas engines cooling towers are common. These have a loss by evaporation somewhat greater than a cooling tank, amounting to 0.4 gal. to 0.5 gal. per brake horsepower hour. In these methods of cooling by air, the temperature to which it is possible to cool the water dealt with is, of course, absolutely dependent on air temperature as registered by the wet-bulb thermometer, and the nearer it is desired that the water shall approach the temperature of the air the larger and more expensive the cooling plant becomes. The efficiency of a cooler depends almost entirely on the means adopted to bring the water into intimate contact with the air.

An interesting cooler, which has recently been introduced claims a minimum consumption of water per brake horsepower hour, and has the advantage of being compact and occupying comparatively small space. The apparatus is also self-contained. It is of the stationary type, and has no moving parts beyond the fan which circulates the air and the pump which circulates the water. The apparatus consists of a rectangular casing built up of mild steel plates and stiffened with angles where necessary. The base forms a tank into which the water drains after cooling, ready to be returned to the engine jackets, or to whatever other service the cooler is used in connection with. Cooling is obtained by distributing the water over a number of horizontal screens set up, one above the other, in the body of the cooler. The water enters through a strainer at the top, which can be seen in the figures, and falls onto the screens through nozzles which feed perforated troughs. In its fall through the screens, it meets a current of cold air which is forced through the casing by a centrifugal fan. The fan is fixed at the top of the machine and the air passes down a trunk at the side as shown.

The screens are formed of brass or phosphor-bronze metallic wool, of standard size and thickness, held together between brass wire netting which is attached to galvanized angle-steel frames. The screens rest on angle brackets and are easily removed, for inspection or cleaning, through a side door. Experience shows that removal is seldom necessary. Across the upper part of the cooler casing a number of eliminators are fixed. These consist of curved galvanized steel blades and are designed to arrest the diffusion of water in the form of loose particles by the current of heated air which emerges from the top of the cooler.

The fan runner is keyed to a shaft which is enclosed in a tubular casing, this casing passing through the upper part of the cooler. The fan is mounted at one end of the shaft, while at the opposite end is fixed a driving pulley with two diameters. The main drive is on the larger of the two and from the smaller diameter a belt drives the centrifugal water-circulating pump which is fixed at the bottom of the machine. In an alternative arrangement an electric motor drives the pump direct, and a pulley mounted on its main spindle drives the fanshaft through a belt. It will be clear that there are no moving parts in the cooler except the fan and pump, and no parts subject to derangement. The fan deals with dry air from the surrounding atmosphere, and is not immersed in saturated air, which might cause corrosion.

In the ordinary standard sizes the machines vary in capacity from 625 gal. per hour to 55,000 gal. of water cooled per hour. A medium-sized cooler working in conjunction with, say,,a petrol engine or dynamometer can deal with 10,000 gal. of water an hour and cool it from 170 to 100 deg. F., extracting 7,000,000 B. t. u. per hour. Working with, say, an air compressor and dealing with the same quantity of water, it could cool from 85 to 75 deg. and extract 1,000,000 B. t. u. per hour. These figures assume temperate climatic conditions.



SECTION THROUGH SELF-CONTAINED WATER COOLER

As the machine is completely enclosed, it can be placed in an engine-room without the atmosphere becoming impregnated with moisture, the heated air discharged being, of course, led away. In connection with the use of the apparatus for dealing with the cooling water of air compressors, it will be evident from our description that it might alternatively serve as an air cooler and filter. Dust and dirt suspended in the air would be washed out in its passage through the machine, and if cold water were used it would also be greatly reduced in temperature. The effect would, of course, depend on the difference between the temperatures of the air and water.—Engineering.

THE CAUSE is too great to allow petty jealousy and spite to dominate. Be a booster for humanity. Unite, co-operate and let's save souls.

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Issued the 1st and 15th of each month. Established over 24 yr.

Published by the TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago.
New York Office, 150 Nassau St.

Subscription price $1.50 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.00 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 10 cents; back numbers, 20 cents.

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Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue 22,300

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Fair Working Agreements

EVIDENTLY an agreement or bargain implies two responsible parties who have agreed to a certain performance and intend to carry out the agreement. This implies free will on the part of both and ability to do what has been promised, with sincere intent to do so.

It is usually considered that before entering into an agreement each party should satisfy himself of the ability of the other to carry out the agreement, but the bargain itself is taken as the evidence of sincere intent. Where there is doubt, a bond is given as security for satisfactory performance.

In the case of labor agreements, there seems to be a feeling of uncertainty as to whether they will be carried out or not. In a contract for material or construction, the contractor is held liable for damages if he does not fulfil his obligations, and there seems, in fairness, no reason why an employe who makes a contract either as an individual or as one of a group should not accept the same responsibility as an employer.

Employers, both individuals and firms, are of a mind to be just in their dealings with employes; but, if they are not to meet the same mind in the workers, they can hardly be blamed for distrust of the motives and responsibility of employes and their representatives. The difficulty seems to be, not with individual employes, who like the majority of men are sincere and responsible, but with collective action of these workers, in which for some reason of agreement is that they are losing sight of the fair principles of agreement which they recognize when acting as individual men.

In a recent referendum vote of the Chamber of Commerce of the United States, twelve principles of industrial relations were adopted by almost unanimous vote, and these seem to form a basis for fair working agreements based on freedom of action and intent of responsible performance. In substance, they are as follows:

1. The right of every person to engage in any lawful business or occupation and to make individually or collectively any lawful contract, subject to limitation by valid exercise of public authority.

2. The right of open shop operation for employer and employe as an essential of the right of individual contract.

3. The right to associate voluntarily for any lawful purpose, but without authority over limitation of the rights of those who do not desire to enter the association.

4. Public welfare, protection of the individual and sound relations require that all associations be subject to the authority of the state and legally responsible for their conduct and that of their agents.

5. Having due regard to health, safety and wellbeing of individuals, all engaged in an industry are responsible for developing its output to meet the public needs, and restriction of productive effort or output in order to create artificial scarcity is an injury to society.

6. Wages of labor must come out of the product of industry and must be measured by its contribution to that product. It is the duty of management to endeavor: (a) to secure continuous employment for the worker suited to his abilities; (b) to give incentive and opportunity for improvement; (c) to safeguard health and safety and; (d) to encourage increase in the value of

product, so that the worker may earn wages sufficient to sustain him upon a proper standard of living.

7. Daily or weekly hours of work for maximum output consistent with well-being of the worker should be ascertained by careful study and not exceeded except in emergency; one day of rest in seven should be provided. Reduction below this ascertained period to give increased leisure to workers should be made only with understanding and acceptance of the fact that it means reduced output and earning power of workers, shortage of output, increase in cost of product and the consequent effects on the workers, and the community.

8. Adequate means, satisfactory to employer and employes and voluntarily agreed to, should be provided for prompt and just settlement of all questions that arise in industrial operations.

9. Where dealing between employer and employe is not direct, but through representatives, such representatives should not be chosen, controlled by or represent for the question at issue any outside group or interest.

10. The true basis for sound industrial relations is intelligent and practical co-operation between employer and employe, based on community of interest, full development of the particular establishment with which they are associated, and the greatest measure of reward for both, consistent with full social value of their service.

11. Government employes, national, state or municipal, have the right to be heard, and consideration and just treatment must be safeguarded, but community welfare demands that no combination to impair the operation of government or any of its functions be permitted.

12. In public service utilities the public welfare requires that regulation and protection by the state over the corporation should extend to employes so far as necessary to insure adequate and continuous operation of the service.

In considering these principles as a basis for industrial relations, it is probable that every fair minded man will agree to them as a right basis for the conduct of the other fellow's business. If that is so, then they must be a right basis for one's own business or occupation and should be so accepted.

Their acceptance by all employers and employes will go far to do away with industrial unrest, disagreements and injustice, and to bring about the stable conditions in industry which are so imperative to the welfare of the country and its people.

Off Duty

During the early days of the telephone, when it was in the first stages of its development as a commercial possibility, one of the most annoying difficulties the telephone companies had to contend with was the fact that after using the instrument, the subscribers would forget to turn the switch provided for the purpose of disconnecting the telephone from the line. As a consequence, service was interrupted until such time when they happened to notice it (which they never did) or until a trouble shooter was sent from the telephone company. Continual instruction and repeated warnings proved ineffectual—a certain number of the subscribers continued to forget.

One day, however, a man sat down with a telephone instrument before him and pondered over the problem—how could he arrange the switch on the instrument so that the people could not forget to open it? In his mind he pictured a person using the telephone; first, they closed the switch, then they proceeded with the conversation, and, finally, when through talking, they put the receiver somewhere. That made him think—they put the receiver somewhere. They either placed it on a shelf or on the table, or laid it down on a book, in fact, any place they found convenient. So, he reasoned, why not provide a hook for it which would be more convenient than any other place for depositing the receiver, and, at the same time, let the hook serve as a switch. And so our modern form of receiver hook was born.

Simple, was it not? Yes, and tremendously successful. So successful, in fact, that nobody has been able to improve upon this idea in all these years, and probably nobody ever will.

Why?

Because that man used sound common sense; and by using common sense, he accomplished as much as a dozen men of high technical ability could have done without it.

How many of us, today, use common sense in performing our daily work—our work in the power plant? It wouldn't take long to find out. The man possessing sound judgment and common sense invariably stands out—his work and achievements speak for themselves. He is a success, no matter whether he be an engineer, a lawyer, a carpenter, or a shoemaker.

Of course, we do not for a moment mean to convey the impression that these qualities which we designate as "Common Sense" and "Reason" will stand alone. Especially in the engineering field, they must be accompanied by technical training, and the brain, and ability, without which no man may rise to a dominating position in his profession.

But common sense is essential. Innumerable cases have occurred where an erroneous decision was reached by men of great ability just because they allowed their judgment and experience to be overruled and biased by an extremely technical conception of things.

Develop your common sense—it is not a rare gift. Trust it, and have confidence in it. For success an engineer must have confidence in himself and in his judgment. It is that confidence in himself, backed up by his own common sense and the proof of actual accomplishment, which commands that return in money and reputation which we call success.

Power Plant Slogans

Store Coal in Summer.
Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

The Balanced Skip-Hoist Transporter

ALTHOUGH the skip-hoist has been used for so many years, an important improvement has recently been made by which the same skip which elevates the material also serves to transport the material horizontally. In other words, this improvement makes it possible to do with a single machine the work which has previously required two separate machines.

In order that the skip may be able to carry its load both vertically and horizontally without spilling, a radical change has been made in the form of its construction. The ordinary skip is simply a box with open top and equipped with four wheels and a hinged bale. The improved skip has an opening in the upper portion of the front side for receiving its load and single or double hinged doors on the opposite side for discharging the load when the skip is running on a horizontal track.

Filling of the skip is accomplished preferably by a chute from a hopper. The gate controlling the flow of material through the chute may be operated by hand or an automatic filling device may be installed by which the right amount of material is measured and discharged into the skip without requiring any manual labor or attention of operator. Automatic skip-loading chutes of this kind have been in successful operation for many years.

FIG. 1. THE IMPROVED TYPE OF SKIP

The doors, or valves, of the skip are held in the closed position by a latch. Discharging of the skip's load is accomplished by the tripping of this latch. For installations having a fixed point of discharge, the latch-trip is fixed in position alongside the track; if, however, it is desirable to dump the skip at different points along its horizontal travel, as in the case of filling the overhead coal bunker of a boiler house, the latch-trip may be easily shifted along the track as required. A further improvement consists in having the trip carried on a traveling frame, which is moved back and forth by a hand winch conveniently located.

An important feature of this improved skip-hoist consists in the balancing of the entire weight of the skip and half of its load by a counterweight which operates only during the vertical motion of the skip. In lowering the empty skip, the motor works to raise the counterweight, doing the same amount of work as in hoisting. As the weight of the skip is frequently as great as that of the load itself, the effect of this arrangement in such a case is to reduce the size of the motor and the unbalanced strains in the hoisting machine to one-quarter of what is required for the ordinary unbalanced hoist or to one-half of that for the less common type of double hoist, in which two skips are used to balance each other. A second counterweight of nominal size is employed to take up slack rope paid out from the hoisting drum during horizontal travel of the skip.

On reaching the top of the vertical rise, the skip engages and carries along with it a bar which is connected by cable to a third counterweight which operates to pull the skip backward after being discharged.

Manual labor in connection with the skip-hoist is reduced to a minimum by the installation of automatic switches which reverse the motor at both ends of the skip's run. By this means, in combination with the automatic filling device, the skip-hoist is made entirely automatic in its operation and requires the occasional services of an operator only to keep the machinery oiled and to shift the traveling tripper, in case this is used.

The skip may be of any suitable capacity, and the height of lift and length of run of any reasonable distance to suit the requirements of an installation. Assuming the ordinary case of a boiler house with a skip-hoist transferring coal from a railroad track hopper to an overhead bunker, an equipment of this improved type having a skip of one ton capacity with a travel speed of 500 ft. per minute, will handle coal at the rate of 80 tons per hour. With a skip of two tons capacity, the rate of handling is increased to 150 tons per hour.

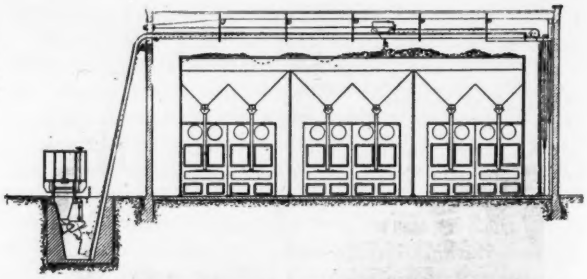


FIG. 2. APPLICATION OF THE BALANCED SKIP-HOIST TRANSPORTER TO POWER HOUSE WORK

Besides its use for handling coal to boiler house bunkers, this skip-hoist transporter is well adapted for use by dealers in coal and building materials in handling these from track hoppers to elevated bins or open storage.

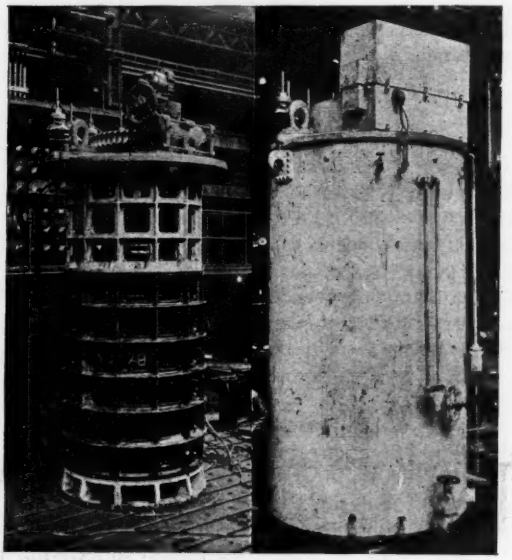
IN VIEW of the experience that has been gained in recent years on the relative merits of copper and iron cooling coils for water cooled transformers, it was deemed advisable to summarize the information to date in this year's report of the Electrical Apparatus Committee of the N. E. L. A.

The report states that copper cooling coils have the advantage of non-corrosibility, the disadvantage of high first cost and a limitation to a pressure of about 250 lb. per square inch maximum. In the iron cooling coils corrosion will take place where the water is unsuitable, principally due to excess air in the water, unless precautions are taken, and these may not always be successful in eliminating the trouble. The advantage in the use of the iron coils lies in cheaper first cost and the ability to stand a maximum pressure of approximately 1000 lb. per square inch.

The use of copper cooling coils is recommended wherever the water conditions are unknown, always bearing in mind the limits of the copper coils where high heads of water have to be considered. Iron coils of less than 1 in. internal diameter should not be employed.—Electrical Record.

New Development in Induction Feeder Regulators

WHAT are claimed to be the largest induction feeder regulators so far produced have recently been installed by the Philadelphia Electric Co., in a new design and application of feeder regulators. These regulators are 1750-kv.a., 3-phase, 60-cycle, 13,600-v., 9 per cent, 830-amp. secondary, oil-insulated, water-cooled, motor-operated. They are of the outdoor type, two of them being installed, each arranged to regulate a 20,000-kw. circuit.



1750-KV.A. REGULATOR COMPLETE WITH AND WITHOUT TANK

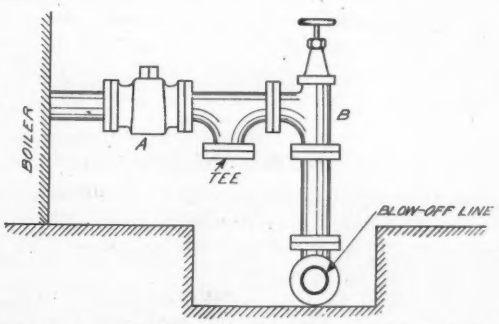
By the installation of these regulators, the rating of each of the two 66,000-v. tie lines between the Schuylkill and Chester generating stations has been increased from 15,000 kv.a. to 20,000 kv.a. Even when the lines are carrying full rated kilovolt-ampere load the station bus voltages will not differ greatly.

Safety Tee in Boiler Blowoff Line

TO THE man who is cleaning boilers, one of the greatest and most common sources of danger to personal safety is the danger that somebody is going to turn hot water and steam into the boiler in which he is working, by way of the blowoff line. Many times a number of boilers will be connected to a common blowoff line, each boiler, of course, being connected to the line through a blowoff cock and also a blowoff valve. Now, under ordinary operation, both of these valves are closed and remain closed until the boiler is to be blown.

The common practice in nearly every plant is to sludge the mud and scale from a boiler that is being cleaned into the blowoff line and get rid of it in that way. Now, right there is where the danger lies. A man is inside one boiler cleaning it out, sludging his mud, etc., out through the blowoff line. The water-tender, unless he is careful and has been warned of the existing condition, is liable to open the blowoff cock and blowoff valve on a live boiler which he wants to blow down, into the blowoff line. The result is an accident.

In order to prevent this accident from occurring in a Western plant, safety "tees" have been installed between the blowoff cock and the blowoff valve on every boiler. Upon the outlet of the tee is bolted a blind flange. Whenever a boiler is taken down for cleaning, blowoff cock A is opened, and the blind flange removed from the outlet of the tee, while blowoff valve B is left tightly closed.

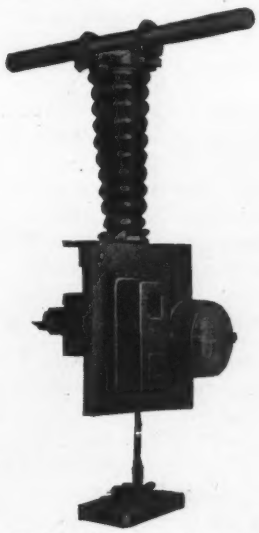


LOCATION OF SAFETY TEE IN BOILER BLOWOFF LINE

Now the man cleaning the boiler can sludge his mud, scale, etc., through the blowoff line, through blowoff cock A and out the outlet of the tee, blowoff valve B being closed, which prevents the backing up of any steam or hot water that may be sent down through the blowoff line from another boiler.

Overload Relays for High Voltage Circuit

FOR the protection of high-voltage alternating-current circuits of 100 amp. or less, an overload relay has been developed which precludes the use of high-voltage current transformers. With this device, ample overload protection is obtained and an approximate time element afforded at a minimum cost.



HIGH-VOLTAGE OVERLOAD RELAY AND METHOD OF MOUNTING

The relay is designed for indoor use and is arranged for pipe mounting as shown in the accompanying illustration. It consists of a circuit-closing element operated by means of a standard current-transformer, an overload relay and a special transfer relay through a micarta chain of such length as to provide ample insulation for the voltage in use. The three units just mentioned are mounted on one base which is in turn supported from an insulator. The overload relay has a 4 to 12 amp. range, and a 2 sec. inverse-definite-minimum-time limit. Operation of this relay serves to close the circuit of the releasing coil on the transfer relay.

The current transformer can be used on all voltages since it is thoroughly insulated from ground and from the remainder of the system.

News Notes

THE 1920 ANNUAL MEETING of the American Society of Mechanical Engineers will be held in the Engineering Societies Building, 29 West 39th St, New York City, from Dec. 7 to 10 inclusive.

Sessions will be held on the subjects of Appraisal and Valuation and the Application of Engineering to Woodworking.

The newly founded professional sections on management, power, fuels, machine shop, railroads and textiles will also conduct sessions to consider the vital problems in their field. In addition, a number of valuable papers will be presented at general sessions.

A memorial session for Dr. Brashear is planned, as a fitting tribute to his life and work.

AT A MEETING of members of the Chicago welding trade, held in the rooms of the Western Society of Engineers, on Tuesday evening, Aug. 3, a Chicago Section of the American Welding Society was organized. There were about 75 in attendance, representing many railroads terminating in Chicago and also many of the larger local industries. The following officers were elected: M. B. Osburn, chairman; O. T. Nelson, vice-chairman, and L. B. Mackenzie, secretary-treasurer. The address of the secretary-treasurer is 608 S. Dearborn St, Chicago.

M. H. DETRICK CO., manufacturer of Detrick Flat Suspended Arches, Detrick-Hagan Steam Jet Ash Conveyors, announces the opening of an Eastern branch office at 30 Church St., New York City. This office will be under the management of R. D. Foltz, former assistant mechanical engineer, who has been appointed Eastern sales manager. Harry S. Sleicher will continue to handle all sales matters in the New York territory.

AT A MEETING of the Federal Power Commission held in Washington, July 27, plans for the detailed organization of that body were agreed upon. In general, the commission will be composed of the following subdivisions: Engineering, accounting, statistical, regulatory, licensing, legal and operating.

The country has been divided into five administrative districts.

District No. 1—Headquarters, Washington, will consist of the territory east of the eastern shore of Lake Michigan, the Illinois-Indiana boundary and east of a line drawn so as to include the Ohio River basin and proceeding irregularly southward to the Gulf at Mobile.

District No. 2—Headquarters, St. Paul, includes that territory west from District No. 1 to midway in the Dakotas and north of Muscatine, on the Mississippi, and Sioux City, on the Missouri.

District No. 3—Headquarters, St. Louis, includes the Mississippi basin south of District 2 and all of Kansas, Missouri, Arkansas, Louisiana, Texas, and sections of Mississippi, Nebraska and New Mexico.

District No. 4, with headquarters at Denver, includes the greater part of the states of Montana, Wyoming, Utah and Colorado and parts of North Dakota, South Dakota, Nebraska and New Mexico.

District No. 5 includes, in addition to the coast state, Idaho, Nevada and Arizona. It has its headquarters at San Francisco.

Trade News

GREENE, TWEED & CO. announces to all operators of steam power plants the completion of arrangements to manufacture its Rochester automatic lubricators in its new plant at Newark, N. J. This plant is to be under the personal supervision of one of the company's vice-presidents and has been equipped with new and modern machinery. All shipments will be made from Newark and all repairing will be done there instead of at 109 Duane St., New York, as formerly.

IN VIEW of the present great scarcity of fuel and the unusual public interest in the economical consumption of it, the Uehling Instrument Co., 71 Broadway, New York City, has decided to exhibit its fuel saving devices at two of the leading expositions of the year, namely, the Chemical Show, Grand Central Palace, New York, Sept. 20-25, and the National Association of Stationary Engineers Convention, Milwaukee, Wis., Sept. 13-17.

The principal products to be displayed will be the new "Style U" CO_2 recording equipment, Uehling pyrometers and draft gages.

YARNALL-WARING CO., manufacturer of Yarway power plant devices, Chestnut Hill, Philadelphia, Pa., is sending out Bulletin B-410, descriptive of Yarway seatless and Yarway double tightening blowoff valves, both separately and in combination. The Yarway double tightening valve is a new development, having been designed primarily to use in conjunction with Yarway seatless valves in certain states where boiler laws require use of either two valves or a blowoff valve and a cock on each individual blowoff line. This conforms with the A. S. M. E. boiler code.

Those interested in boiler blowoff valves may receive copies of this bulletin on request.

HOISTING HINTS is the title of a new booklet from the Yale & Towne Mfg. Co., Stamford, Conn, illustrating general uses of Yale spur-geared chain blocks, also describing Yale screw-geared chain blocks and differential chain blocks.

ROOTS' Rotary Positive Blowers Catalog No. 68 contains 48 pages of description and illustrations, also tables of sizes and capacities, and engineering data. The manufacturer is P. H. & F. M. Roots Co., Connersville, Ind.